Susitna River Basin Study - Alaska

USDA INVESTIGATIONS AND ANALYSES

Summary Report

by
U.S. Department of Agriculture
in cooperation with
State of Alaska and the
U.S. Fish and Wildlife Service

July 1985

Final Report

SUSITNA RIVER BASIN STUDY, ALASKA

SUMMARY OF USDA INVESTIGATIONS AND ANALYSES

Prepared by

United States Department of Agriculture

In Cooperation with

State of Alaska

and

United States Fish and Wildlife Service

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July 1985

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Executive Summary

This report discusses investigations conducted by the U.S. Department of Agriculture as part of the Susitna River Basin Study. Major findings resulting from these investigations are as follows:

1. Under only very restrictive assumptions, e.g. zero road construction and zero stumpage costs, is large scale agricultural and/or timber development economically feasible.

2. In order to become self-sufficient in terms of agriculture, the State of Alaska would need roughly 1 million acres of land in production.

3. Under existing conditions, demand from Anchorage and the Matanuska-Susitna Borough for timber land totals about 1.8 million acres.

4. Approximate amounts of state-owned basin land identified as being physically capable of supporting varied uses are as follows (these acreages are not mutually exclusive):

a.	Agriculture	400,000 acres of cultivable soils.
b.	Timber	900,000 acres with high or moderate potential for commercial[1/] timber management.
c.	Settlement	700,000 acres. (In addition, 360,000 acres of Native-owned and 300,000 acres of non-Native-owned private land are physically suited for settlement; in addition to much of the borough's approximately 350,000 acres. Most private and borough settlement lands have better road access than state-owned settlement lands.)

5. Within the Beluga and Talkeetna portions of the basin, approximately 3.8 million wetland acres were identified.

6. Flood plain management studies identified approximately 329,000 acres within the 100-year flood plain.

7. The present value of selected recreational activities taking place within the basin is 220.7 million dollars.

8. Unit values of selected fish and game species were calculated and are included in this report.

1/ Commercial forest land: Forest land producing or capable of producing crops of industrial wood and not withdrawn from timber utilization. Areas qualifying as commercial forest land have the capability of producing in excess of 20 cubic feet per acre per year of industrial wood under management.

9. A methodology was developed for identifying a minimum land base necessary for maintenance of fish and wildlife resources.

10. A methodology was developed for estimating costs associated with accessing basin land.

11. Three cultural resource inventories and assessments were prepared and are summarized in this report.

INTRODUCTION

I. Introduction

A. Background

In recent years, the State of Alaska and the Matanuska-Susitna Borough have been transferring land to private ownership in the Susitna River Basin. These transfers are often accompanied by title restrictions for each particular parcel in question, i.e., the state or borough withholds certain development rights and allows only land uses it deems are best suited.

In the past, "best uses" were at times determined with insufficient data because adequate inventory information simply did not exist. As a result, in many instances inappropriate uses evolved on basin lands. For example, homes were built in flood plains and septic tanks were constructed in or adjacent to wetlands. In addition to physical compatibility problems, social and environmental tradeoffs became major issues. The best wildlife land was at times the best agricultural or urban land, and disposal of land for its "best use" became even more subjective.

Realizing these problems would grow with both increasing population and demand for land for all uses, and interested in developing a data base for evaluating and selecting appropriate land uses, the Alaska Department of Natural Resources (ADNR) requested technical assistance from the U.S. Department of Agriculture, Soil Conservation Service (SCS) in February 1976. In response, the USDA, in June 1976, authorized the Alaska River Basin Study under Public Law 83-566 (Watershed Protection and Flood Prevention Act of 1954).

Public Law 83-566 provides broad authority for cooperation between USDA agencies and other Federal and state agencies in river basin planning, surveys, and investigations. The SCS directs these activities, working closely with the USDA Forest Service (FS) and Economic Research Service (ERS). Conducted at the request of cooperating agencies, in this case the ADNR, river basin studies are undertaken to:

- identify water and land resource problems,
- analyze the economic base and environmental setting of the study area, and
- suggest alternative plans for solving identified problems and improving the economy and environment.

In February 1979, a plan of work for the Susitna River Basin Study was adopted. For study purposes, the Susitna River Basin was divided into four subbasins: Willow, Talkeetna, Beluga, and Upper Susitna (Figure 1). The Willow Subbasin Study was scheduled first. Completion of that study resulted in a land use plan for the Willow Subbasin, published in October 1982 as: Willow Subbasin Area Plan, A Land Use Plan for Public Lands (ADNR, Matanuska-Susitna Borough, ADF&G, with the assistance of the USDA SCS). USDA activities during that study are summarized in: Susitna River Basin Study - Alaska, Willow Subbasin (USDA in cooperation with the State of Alaska and the U.S. Fish and Wildlife Service, 1981). After completion of the Willow land-use plan, a combined study of the final three subbasins was initiated.

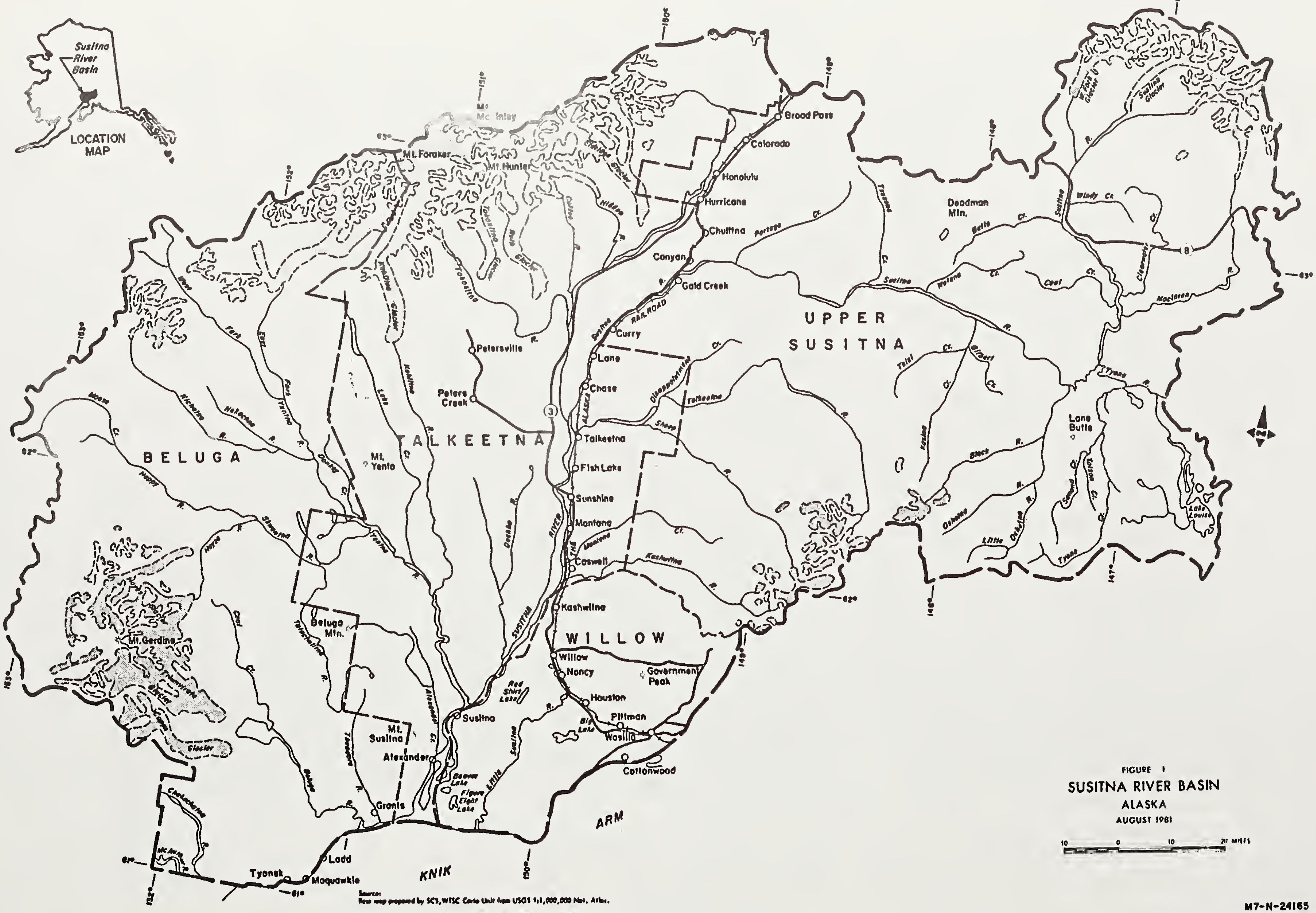

FIGURE 1

SUSITNA RIVER BASIN

ALASKA

AUGUST 1981

10 0 10 20 MILES

Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:1,000,000 Nat. Atlas.

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M7-N-24165

This report summarizes information gathered and developed by the USDA during the combined study of the Talkeetna, Beluga, and Upper Susitna Subbasins. Although this report is not meant to stand alone as the final river basin report, it informs readers of types of data collected and analyses made by the USDA. The land-use plan developed using these data and analyses is described in: Susitna Area Plan, Public Review Draft - Summary (ADNR, ADF&G, Matanuska-Susitna Borough, in cooperation with ADOTPF, Kenai Peninsula Borough, USDA, and BLM, 1984).

Supplementary reports discussed herein are listed in Appendix A. These reports, maps and computerized data are available at either:

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B. Study Objectives

Reasons for state and borough participation in this study are obvious: as they transfer their lands to the private sector, they must determine both the locations and amounts of land to transfer for each type of land use, e.g., for agriculture, timber, settlement, etc. To assist the state and borough in making decisions about which lands to transfer, the USDA undertook to provide resource data and analyses that would facilitate state and borough land use planning and management in the Susitna River Basin.

More specifically, the state and borough requested that the USDA provide the following information and assistance:

1. An economic analysis of the benefits and costs associated with timber and agricultural development in the Susitna Basin.

2. Estimates of state and local land demands for agricultural and timber products, i.e. the amount of land required for the state to become self-sufficient in agricultural and timber production.

3. Based on the results of number 1 above, a determination of costs associated with accessing agricultural and timber resources.

4. Resource inventories and analyses of the following:

   a. water resources
   b. soils
   c. land treatment and agronomy
   d. geology
   e. land cover and vegetation
   f. recreation
   g. archeological, historical, and cultural resources
   h. fish and wildlife and wetlands
   i. flood plains

5. Estimates of the economic value of selected recreational resources within the basin.

6. Assistance in developing an integrated automatic data processing capability to handle collected resource data.

Each of the preceding objectives is addressed in more detail in the "Analysis and Results" section of this report.

C. The Study Area

The Susitna River Basin encompasses approximately 14 million acres in Southcentral Alaska (Figure 1). Of this total, about one million acres lie in the Willow Subbasin, for which a similar study has been completed and published (Susitna River Basin Study - Alaska: Willow Subbasin Final Report, 1982, USDA in cooperation with the State of Alaska and the U.S. Fish and Wildlife Service). The remainder of the basin, addressed in this report, extends from Cook Inlet on the south to the Alaska Range on the north, Clearwater Mountains on the northeast, Lake Louise area on the east, and Tordrillo Mountains on the west. Major stream systems are the Susitna, Talkeetna, Chulitna, Kahiltna, Skwentna, Yentna, and Beluga Rivers, and the lower reaches of the Chakachatna River. Lakes in the area number in the hundreds, among the largest are Lake Louise and Beluga Lake, as well as Alexander, Strandline, Trapper, Shulin, Chelatna, and Amber Lakes.

Basin communities (excluding those in the Willow Subbasin) include Talkeetna, Skwentna, Trapper Creek, and Tyonek. The study area includes most of the Matanuska-Susitna Borough and the northwestern portion of the Kenai Peninsula Borough. The study area is traversed from north to south by the Parks Highway and the Alaska Railroad. Access to much of the area is primarily by airplane, boat, or all-terrain vehicle.

ANALYSES AND RESULTS

II. Analyses and Results

This section is divided into six subsections, one for each of the objectives listed above. Each subsection contains four parts: 1) restatement of the objective, 2) rationale for the objective, 3) discussion of research conducted to meet the objective, and 4) a summary of research and analysis results.

A. Objective: Provide an economic analysis of the benefits and costs associated with timber and agricultural development in the Susitna Basin.

Rationale: To determine whether or not state and borough land disposals for agricultural and timber development are economically feasible.

Analysis: In this analysis, returns from investments (benefits) were compared with investment expenditures (costs) for several agricultural and timber development activities. Costs considered included road construction, land clearing, and other operations associated with logging and farming; and these were evaluated for several sets of alternative economic conditions. The primary benefit measured was dollar value of increased supply of commodities resulting from investment activities, commodities in this case being barley, sawlogs, and fuelwood.

In order to examine development costs associated with undertaking agriculture or timber production in specific locations; that is, in order to facilitate "disaggregated" and geographically localized analysis, the study area was subdivided into 50 smaller areas called land production (LP) units (Figure 2). The LP units were delineated in areas where the best soil and timber resources are located, as indicated by soil and vegetation surveys.

The analysis identified benefits and costs of 25 different alternatives, with each alternative being characterized by 21 parameters or variables, such as changing market prices, different crop yields, etc. Appendix B identifies the variables (assumptions) used in the analysis and presents the results of analyzing each alternative.

Results: Results from analysis of alternatives 1 through 4 indicate that barley production is not profitable at an export price of $3.12 per bushel.

Of the remaining 21 alternatives, 13 indicated a positive net benefit from domestic barley production. The number of acres that could feasibly be put into production ranged from a low of 2,096 in alternative no. 6 to a high of 273,512 in no. 23. Six of the economically beneficial alternatives suggested that it could be feasible to bring 150,000 acres or more into production; however, the USDA considers one or more of the assumptions used in these six alternatives to be overly optimistic at this time, i.e. the USDA does not recommend large-scale barley production in the Susitna River Basin at this time. Results indicate that economic feasibility is most sensitive to production costs, yields, and prices received.

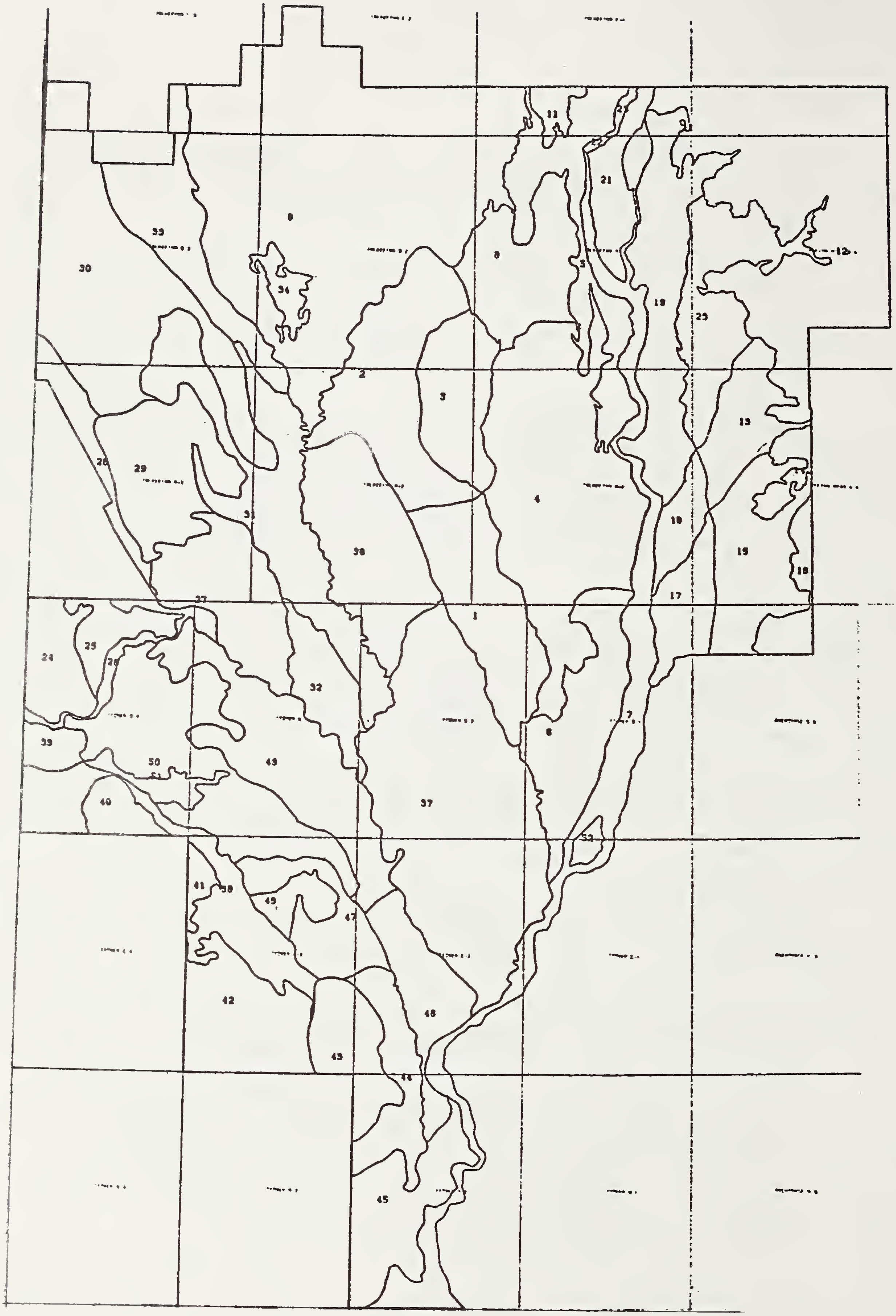

Figure 2

From the standpoint of timber products, analysis indicates that production is economically feasible under almost all alternatives evaluated. Two very important points to note are:

1. Stumpage costs, i.e. the costs of the right to cut timber, were zero in all alternatives, and

2. In only one of the 25 alternatives were profits high enough to pay for road construction.

In short, if free cutting is allowed and existing roads are used, profits can be made. Otherwise logging operations become marginal given current prices and cutting methods. For further discussion of these economic analyses, refer to Appendix B.

B. Objective: Provide estimates of state and local land demands for agricultural and timber products, i.e. the amount of land required for the state to become self-sufficient in agricultural and timber production.

Rationale: To provide information sought by significant special-interest groups within Alaska, as well as by legislators, who believe pursuing the goal of self-sufficiency in these commodities has many desirable effects, among which is greater security for Alaskans in times of international crises when routes of supply may be severed.

Analysis:

1. Agricultural Analysis

This analysis identified the total number of productive acres needed to achieve self-sufficiency in those crops that can be grown in Alaska. Total acreage figures are based on both per capita demand and land required in production to meet demand.

Number of acres needed in production depends heavily on crop yield assumptions and human population projections. There are immense differences in the ability of various parcels of land to produce a particular quantity and quality of a certain crop. Since yields and yield projections vary greatly at different times and in different areas of Alaska, the amount of land needed to satisfy in-state demand for different agricultural products has been calculated under various yield assumptions. The higher the assumed yield, the less land is required to produce a particular quantity of product.

This analysis does not consider whether or not meeting the in-state demand from local supplies is economically feasible.

2. Timber Analysis

The forest products demand analysis identified the Matanuska-Susitna Borough and Anchorage demand for selected timber products, as well as the land base necessary to provide these products. As in the Agricultural Land Demand analysis, no consideration was given to whether or not meeting this demand with Alaskan sources would be economically feasible.

Results:

1. Agricultural Results

Tables 1 and 2 summarize the results of the agricultural analysis. Information developed indicates that land required to meet current in-state demands for Alaskan agricultural products ranges from 666,200 to 1,216,000 acres, while year 2000 demand requires production from somewhere between 1,065,100 and 1,944,000 acres. Midpoint cropland needs for existing and projected year-2000 populations are 941,100 and 1,504,550 acres, respectively. All acreage figures in Table 2 (e.g., those cited above) represent "harvested" as opposed to "planted" acres. On the average nationwide, for years 1978, 1979, and 1980, planted acres exceeded harvested acres by about 10%; therefore, estimating total agricultural land required to meet in-state crop demand requires an adjustment to account for this 10% discrepancy. Adjusted midpoint land requirements for existing and projected year-2000 populations are 1,035,200 and 1,655,000 acres, respectively.

Table 1. Existing Supply and Demand of Selected Agricultural Commodities

Agricultural Commodity	Per Capita 1/ Demand (lbs.)	Total Alaska 2/ Demand (1000 lbs.)	1981 Alaska Supply (1000 lbs.)	Imports to the State Quantity (1000 lbs.)	Imports to the State Percent
Potatoes	74.8	31,580	9,500	22,080	69.9
Vegetables	158.3	66,832	2,320 3/	64,512	96.5
Beef & Veal	124.3 4/	52,478	749	51,729	98.6
Lamb & Mutton	2.0 4/	844	18	826	97.9
Pork	56.1 4/	23,685	293	23,392	98.8
Poultry	49.3 4/	20,814	231	20,583	98.9
Milk	546.0 5/	230,514	13,400	217,114	94.2
Eggs	35.4 6/	14,945	874	14,071	94.2

1/ USDA Agric. Statistics and USDA Food Consumption, Prices, and Expenditures (Nationwide averages).

2/ Assuming a 1981 Alaska population of 422,187. Source: Alaska Population Overview - 1981, Alaska Department of Labor.

3/ Represents 1980 supply; 1981 figures not available.

4/ Dressed weight - For poultry, dressed wt. and retail wt. are assumed to be equal.

5/ Represents milk equivalent of per capita demand for all dairy products.

6/ 1 case = 30 doz. eggs = 47 lbs. (7.66 eggs = 1 lb.).

Table 2. Total Land Demand for Agricultural Purposes

Crop	Assumed yield per acre	Total Demand 1983 (Pop.=422,187)	Total Demand 2000 (Pop.=674,983) 1/
		acres	acres
Barley and Hay	40 bu. barley and 1.0 tons hay	1,204,500	1,925,700
	50 bu. barley and 1.5 tons hay	939,800	1,502,500
	60 bu. barley and 2.0 tons hay	773,400	1,236,600
	70 bu. barley and 2.5 tons hay	658,200	1,052,300
Vegetables	70 Cwt.	9,700	15,500
	80 Cwt.	8,400	13,500
	90 Cwt.	7,600	12,100
	100 Cwt.	6,800	10,800
Potatoes	9 tons	1,800	2,800
	10 tons	1,600	2,600
	11 tons	1,400	2,300
	12 tons	1,300	2,100
	13 tons	1,200	2,000
Total - assuming highest yields		666,200	1,065,100
Total - assuming lowest yields		1,216,000	1,944,000

1/ Source: Alaska Economic Projections for estimating electricity requirements for the railbelt, Batelle Pacific Northwest Labs. - moderate projection.

2. Timber Results

Results of the timber analysis are shown in Tables 3 and 4. Information developed shows that meeting timber product demand requires between 921,600 acres and 2,987,840 acres.

C. Objective: Determine costs1/ associated with accessing agricultural and timber resources.

Rationale: To enable planners and others to identify the most desirable road access routes on the basis of their relative costs.

Analysis: During analysis of road costs, a methodology was developed that can be used to evaluate costs of alternative road routes within the basin. Since the methodology is a "short cut" summary in itself, it is presented in its entirety in Appendix C.

Results: See Appendix C.

D. Objective: Conduct resource inventories and analyses of the following:

1. water resources
2. soils
3. land treatment and agronomy
4. geology
5. land cover and vegetation
6. recreation
7. archeological, historical, and cultural resources
8. fish and wildlife and wetlands
9. flood plains

Rationale: The inherent capability of an area to support particular land uses is a function of physical and biological conditions (e.g., soils, flood history, vegetation, geology, etc.) characterizing that area, and how those conditions promote or constrain implementation of land uses in question. Inventorying physical and biological resources and conditions is, therefore, an essential prerequisite to land capability analysis.

1/ All costs shown are rough estimates only and are not meant to be used as a substitute for "on the ground" reconnaissance and subsequent detailed design and cost work. The purpose of this information is to enable planners and others to identify the more desirable routes of access by means of establishing <u>relative</u> costs among route selection alternatives. Unless otherwise noted all costs are on a 1983 price base.

Table 3. Annual Wood Products Demand 1/

Product	Mat-Su Borough Demand 2/			Anchorage Demand			1983 GRAND TOTAL	2000 GRAND TOTAL
	Per Capita	1983 Total	2000 Total	Per Capita	1983 Total	2000 Total		
Lumber (bd. ft.)	266	6,308,722	20,064,646	266	47,724,060	66,793,132	54,031,782	86,857,778
Plywood/ Veneer (cu. ft.)	7.2	170,762	543,103	7.2	1,291,752	1,807,934	1,462,514	2,351,037
Pulp (cu. ft.)	21.2	502,800	1,599,137	21.2	3,803,492	5,323,362	4,306,292	6,922,499
Fuelwood (cords)	0.81	19,211	61,099	0.15	26,912	37,665	46,123	98,764
Other	1.8	42,691	135,776	1.8	322,937	451,984	365,629	587,760

1/ Based on populations as follows:

Anchorage	1983 =	179,410
	2000 =	251,102
Mat-Su Borough	1983 =	23,457
	2000 =	75,071
Tyonek	1983 =	260
	2000 =	360

2/ Includes Tyonek

Table 4. Timber Land Demand

Demand 1/ Origin	Assumed Volume Per Acre (Net Cubic Feet) 1246 Existing	1500	1800	2100	2400
			acres		
Annual Mat-Su (1983)	3,534	2,935	2,446	2,096	1,836
Annual Anchorage (1983)	18,654	15,496	12,913	11,068	9,685
Annual Total (1983)	22,188	18,431	15,359	13,164	11,520
Annual Mat-Su (2000)	11,239	9,336	7,780	6,669	5,835
Annual Anchorage (2000)	26,109	21,688	18,073	15,491	13,555
Annual Total (2000)	37,348	31,024	25,853	22,160	19,390
80-year 2/ Total (1983)	1,775,040	1,474,480	1,228,720	1,053,120	921,600
80-year Total (2000)	2,987,840	2,481,920	2,068,240	1,772,800	1,551,200

1/ Populations used were as follows:

Mat-Su (Includes Tyonek) - 1983 = 23,717
Mat-Su (Includes Tyonek) - 2000 = 75,431

Anchorage - 1983 = 179,410
Anchorage - 2000 = 251,102

2/ Assumed rotation period.

Results: River Basin inventories were carried out either directly by the USDA (Forest Service, Soil Conservation Service, and/or Economic Research Service) or under contract to the USDA. In most cases, inventory methods used and results obtained are described in a separate report for each inventory. These individual reports are referenced below and, where practicable, also summarized. In addition, all supplementary reports discussed below are listed in Appendix A. No separate report was published either for the geological inventory (which represented a synthesis of existing USGS* and DGGS* data rather than a collection of new data) or for the determination of annual basin precipitation and water yields. Results of these inventories and analyses are presented in their entirety in this report.

Data collected during resource inventories were utilized in developing land capability models, discussed in Section F. As described in Section F, model results were mapped, and those maps were used by the Alaska Department of Natural Resources and the Matanuska-Susitna Borough in making land-use decisions. See Section F for a discussion of the uses of these inventories during land-use planning.

Inventories:

1. Water Resources

During the water resources inventory, Susitna Basin precipitation, water yields, water supplies, and water quality were examined. Three reports were prepared detailing these examinations. The first: Susitna Basin Water Quality Report (B. Rummel, no date) identifies and examines water quality data in terms of the issues and decisions facing land use planners and resource developers in the Willow and Talkeetna Subbasins. Recommendations for maintaining water quality are provided.

The second report: Susitna Basin Planning Background Report - Water Supply and Demand (B. Loeffler, 1980) discusses water resource data available for the basin, analyzes current water supplies and potential problems for eight basin communities, and addresses in general terms water resource concerns related to agriculture, placer mining, and instream flows.

The third report: Susitna River Basin Study - Precipitation and Water Yield (J. E. Merrell, 1979) consists of two maps, one depicting mean annual water yields, the other, mean annual precipitation; and an accompanying narrative. Because of the limited distribution and brevity of this unpublished report, it is presented in its entirety below.

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* USGS: U.S. Geological Survey; DGGS: Division of Geological and Geophysical Survey, Alaska Department of Natural Resources.

Mean Annual Precipitation and Water Yield in the Susitna River Basin

Summary

Maps representing mean annual precipitation (Figure 3) and mean annual water yield (Figure 4) were developed for the Susitna River Basin for the purpose of estimating these two important segments of the hydrologic cycle at any location. Data were collected from 30 climatological and 9 stream-gaging stations in the basin, and from 6 stream-gaging stations near the basin. Only four of the climatological stations have records longer than 15 years.

Mean annual precipitation in the lowlands was estimated directly from available precipitation data; mean annual water yield was then computed as precipitation minus evapotranspiration*. In gaged watersheds lacking precipitation data, mean annual water yield was estimated by distributing measured runoff according to elevation; runoff-elevation relationships were then extrapolated to ungaged watersheds to estimate their annual water yields. Once annual water yields were determined, mean annual precipitation was computed by adding mean annual water yield and evapotranspiration. Evapotranspiration values were developed in a separate study.

Some inconsistencies exist between lowland and upland values of both precipitation and water yield. These arise because estimates for mountainous areas were based on volume measurements from large areas while estimates for lowland areas were based on point measurements by rain gages, which are generally understood to represent a little less than true precipitation. Errors in mapped values are felt to be less than 25% above or below true values.

Physical Setting

The study area included the entire Susitna River drainage, as well as drainages of the Beluga and Theodore Rivers to the west. Tree line in these watersheds ranges from 1000 to 2000 feet above sea level. Below that line, mixed white spruce and birch forests are common on well-drained sites and black spruce forests or muskegs in wet areas. Soils are generally shallow over gravel or glacial till; a deep layer of organic material in various stages of decomposition is common. Vegetation above timber line includes sedges, grasses, herbs, and dwarf shrubs; with stands of alder between tree line and alpine areas. Willows and alders are common along stream channels, both at lower and higher elevations.

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* Precipitation minus evapotranspiration equals water yield; alternatively, evapotranspiration plus water yield equals precipitation. Water yield consists of stream and groundwater outflow.

Basin climate is "Transitional," between "Maritime" and "Continental" Climate Zones (see C. W. Hartman and P. R. Johnson, Environmental Atlas of Alaska, 1978, Inst. of Water Resources, University of Alaska, Fairbanks). Mean annual temperature ranges between 25° and 35°F, with pronounced temperature variations throughout the day and year. Local storms are generally caused when moist air flowing up Cook Inlet from the southwest is cooled, either by orographic uplift or by overriding cold air from Mt. McKinley's glaciers. Cold air draining off mountains and underriding moist incoming air causes heavy precipitation 10 or 20 miles from the foot of basin mountains.

Purpose of the Maps

The maps presented in Figures 3 and 4 were developed to facilitate accurate estimates of mean annual precipitation and mean annual water yield anywhere in the basin. Very little of the area is developed, and precipitation has been measured at only a few points. Much development seems possible and the feasibility and nature of most development depends upon hydrology at proposed sites. For example, developers need to know: how much snow must proposed buildings support? how much water will be available in certain areas for use or disposal? The maps presented here can be used to answer such questions. In addition, seasonal patterns of precipitation are indicated in Table 6.

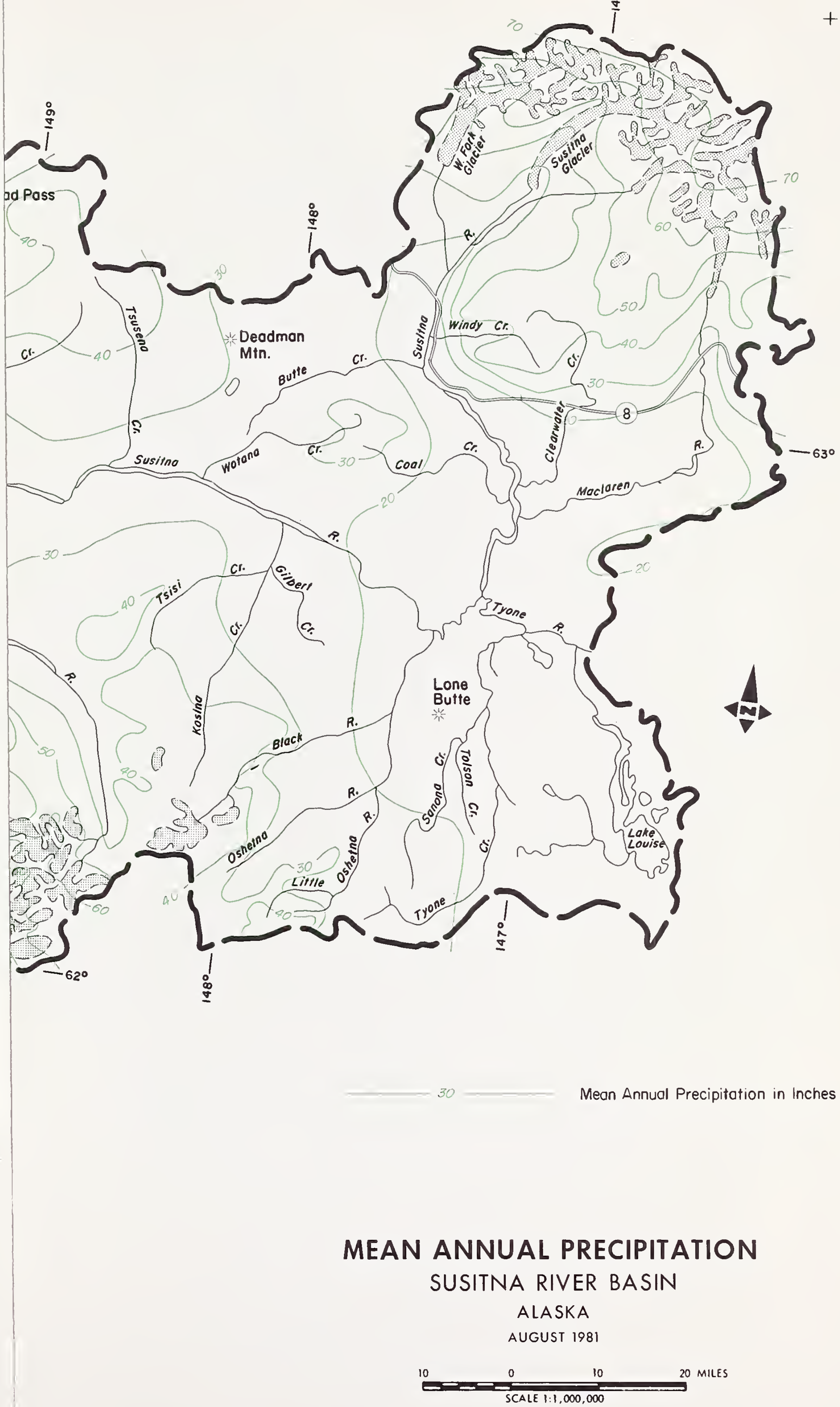
The water yield map must be used with caution in areas with permeable substrata. The map indicates how much water an area will yield, but it cannot specify whether that water will run off the surface or will percolate into the groundwater system and reappear elsewhere.

Previous Work

The most recent mean annual precipitation map was prepared in 1977 by James Wise, Alaska State Climatologist. He recorded on a 1:1,000,000 scale map of Alaska all precipitation data available, and drew isohyets based on them. Orographic effects were accounted for qualitatively because then (as now) few data were available to quantify precipitation in the mountains. His map is considered useful for reconnaissance purposes.

Mean annual water yield had not previously been expressed as mapped isolines. J. W. Freethey and D. R. Scully of the U.S. Geological Survey had, however, derived a formula for its computation. In their publication Water Resources of the Cook Inlet Basin, Alaska (1980, USGS, HA 620), they computed mean annual runoff volume from watershed area, elevation, and precipitation. They used precipitation data from Wise's map, and their results are usable for reconnaissance purposes.

Evapotranspiration data necessary to relate mean annual precipitation to mean annual water yield were developed in 1979 by E. Merrell of the Soil Conservation Service. He calculated evapotranspiration rates from pan evaporation data collected at the Matanuska Agricultural Experiment Station, Palmer. Pan data were extended to higher elevations on the basis of relationships discussed by Patric and Black in Potential Evapotranspiration and Climate in Alaska by Thornthwaite's Classification (1968, USDA Forest Service Research Paper PNW-71, Juneau, Alaska).



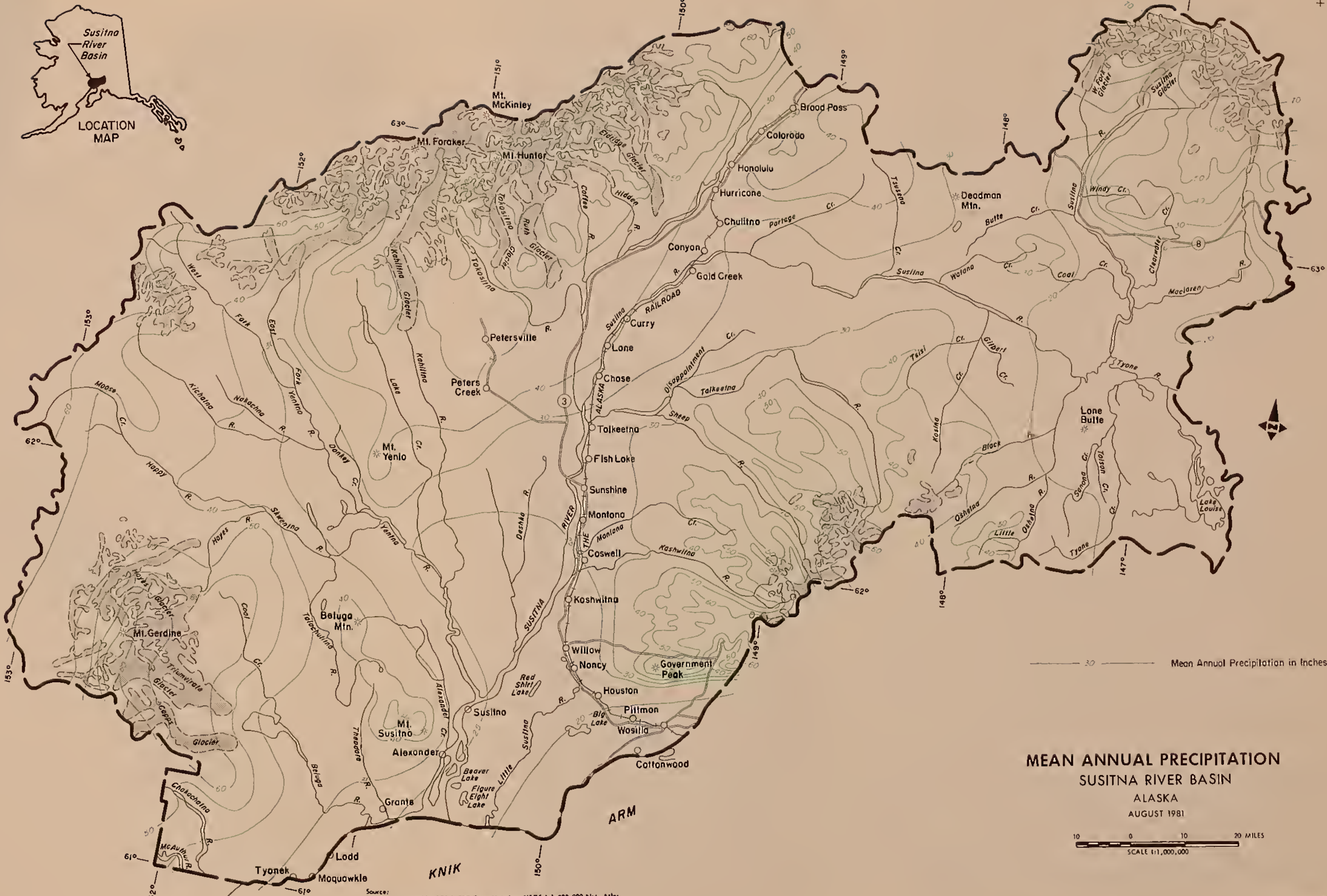
MEAN ANNUAL PRECIPITATION

SUSITNA RIVER BASIN

ALASKA

AUGUST 1981

M7-N-24165-1



MEAN ANNUAL PRECIPITATION
SUSITNA RIVER BASIN
ALASKA
AUGUST 1981

Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:1,000,000 Nat. Atlas.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

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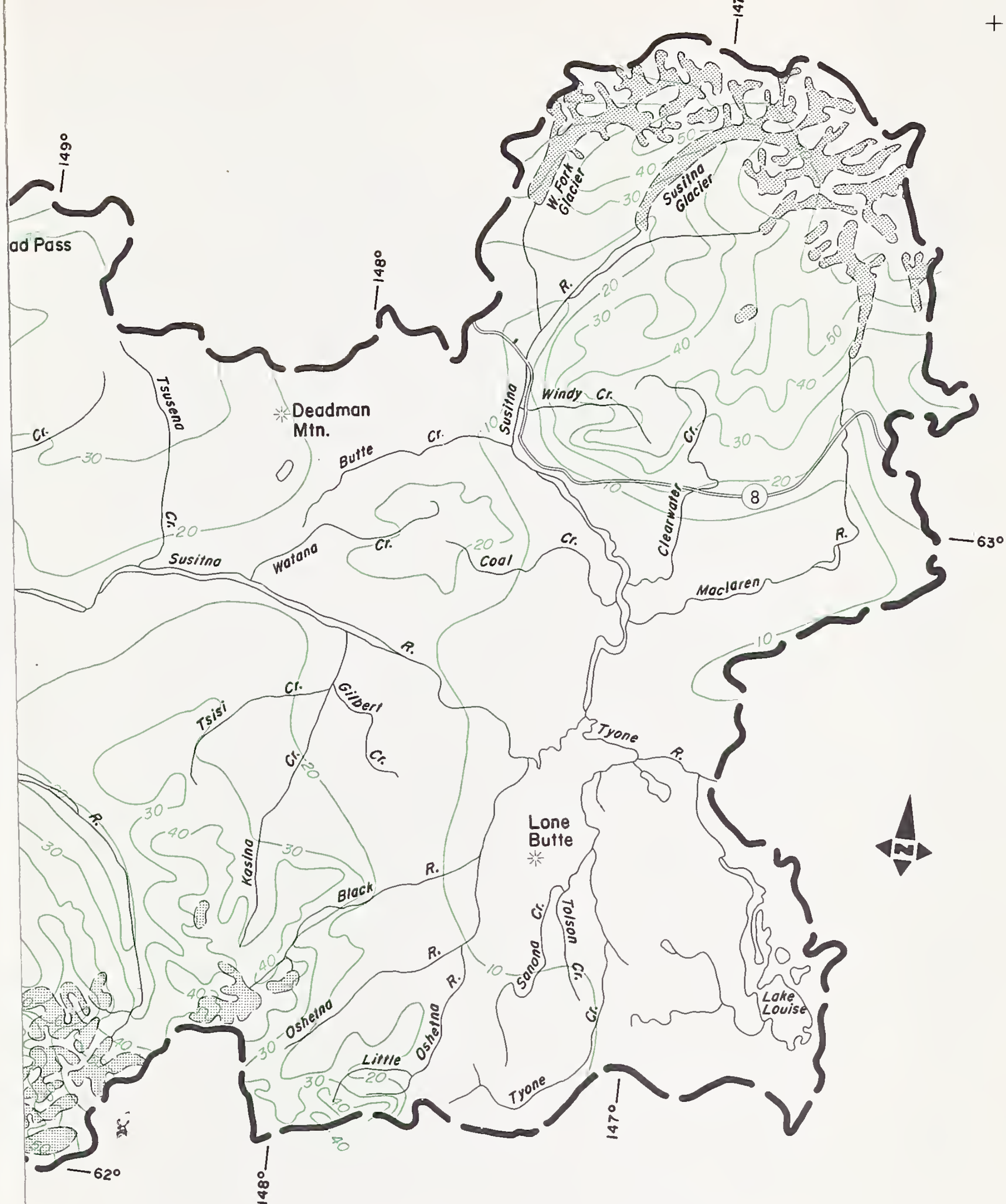


———30——— Mean Annual Water Yield in Inches

MEAN ANNUAL WATER YIELD

SUSITNA RIVER BASIN

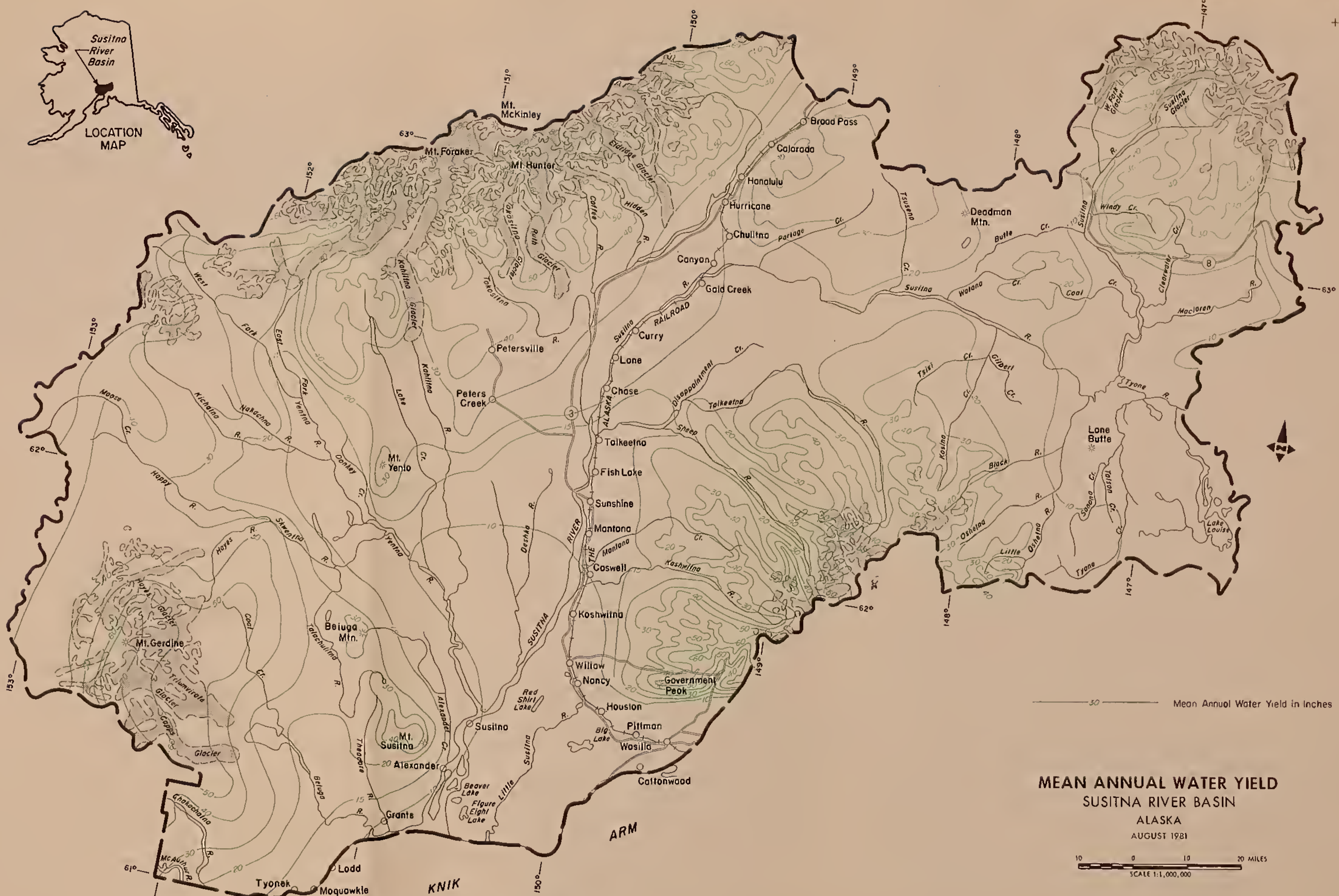
ALASKA

AUGUST 1981

10 0 10 20 MILES

SCALE 1:1,000,000

M7-N-24165-2



MEAN ANNUAL WATER YIELD
SUSITNA RIVER BASIN
ALASKA
AUGUST 1981

SCALE 1:1,000,000

Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:1,000,000 Nat. Atlas.

US DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

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Data Available

Long-term precipitation records (15 or more years of data) were available from only one station in the basin (Talkeetna), short-term records were available from 12 stations. In addition, long-term records were available from Matanuska Agricultural Experiment Station, Palmer; Anchorage Airport, and Elmendorf Air Force Base, Anchorage; and short-term records were available from 17 other stations in the vicinity of the basin. These data were used to determine basin precipitation. Very short records (as short as 2 years) were used by correlating them with precipitation at appropriate long-term stations, and thence to mean annual precipitation. All precipitation data were used as recorded; that is, they were treated as accurate point samples of total precipitation even though it is probable that each rain gage actually measured less than total precipitation at its location.

Mean annual precipitation at sites throughout the basin is presented in Table 5 (along with mean annual temperature and potential evapotranspiration values computed by Patric and Black). Seasonal distribution of basin precipitation was computed from three stations with long-term records, and is presented in Table 6.

Table 5. Data for Mean Annual Precipitation Map

Station	From Climatological Data				From Patric and Black	
	MAP * (inches)	Latitude (North)	Longitude (West)	Elevation (feet)	Mean Annual Temp. (°F)	Potential Evapotranspiration (inches)
Anchorage	14.74	61° 13'	149° 52'	118	35.3	19.25
Beluga	25.	61° 11'	151° 02'	75	-	-
Big Lake	20.7	61° 34'	149° 58'	180	32.8	18.06
Caswell	25.06	61° 58'	150° 01'	290	31.0	18.66
Chickaloon	14.00	61° 48'	148° 27'	929	32.7	18.11
Chulitna Hwy. Camp	42.1	62° 24'	150° 15'	500	-	-
Chulitna R. Lodge	37.	62° 53'	149° 50'	1250	-	-
Curry	43.67	62° 37'	150° 02'	516	34.9	18.94
Eagle R. South Fork	21.	61° 14'	149° 26'	2140	-	-
Edgemire Lakes	40.	62° 32'	150° 17'	760	-	-
Elmendorf	16.24	61° 14'	149° 52'	192	34.8	19.65
Eklutna Lake	12.68	61° 24'	149° 09'	882	30.7	16.93
Eklutna Project	18.46	61° 28'	149° 10'	38	33.7	19.25
Glen Alps	27.	61° 06'	149° 41'	2260	-	-
Healy	17.25	63° 51'	148° 58'	1350	-	-
Goose Bay Nike Site	13.63	61° 24'	149° 51'	100	-	-
High Lake Lodge	24.5	62° 54'	149° 05'	2760	27.1	14.18
Indian River	36.7	62° 45'	149° 50'	735	31.1	16.97
Matanuska	15.49	61° 34'	149° 16'	150	35.5	19.76
McKinley Park	15.12	63° 40'	149° 00'	2092	27.5	14.61
Moose Run	19.2	61° 15'	149° 40'	395	33.0	17.43
Mt. Magnificent	11.	61° 18'	149° 26'	1000	-	-
Rock Ridge Dr.	20.	61° 07'	149° 45'	840	-	-
Summit Nike Site	30.7	61° 15'	149° 33'	3980	29.3	12.69
Skwentna	25.96	61° 57'	151° 10'	153	32.6	18.46
Summit	20.06	63° 20'	149° 09'	2401	25.8	15.51
Susitna	28.05	61° 30'	150° 40'	40	36.0	19.76
Talkeetna	28.64	62° 18'	150° 06'	345	33.2	18.70
Tyonek	21.	61° 04'	151° 08'	50	35.3	19.57
Wasilla 2NE	19.	61° 37'	149° 24'	500	-	-
Wasilla 3S	18.	61° 32'	149° 26'	50	-	-
Whites Crossing	22.	61° 42'	150° 00'	251	-	-
Willow Trading Post	23.	61° 45'	150° 03'	600	32.4	17.28

* MAP = mean annual precipitation.

Table 6. Seasonal Distribution of Precipitation in the Susitna River Basin (monthly percentage of mean annual precipitation)

	Matanuska Ag. Exp. Station	Palmer IN	Talkeetna	Used for Study
January	5	6	6	6
February	4	4	6	5
March	3	3	5	4
April	3	4	4	4
May	5	5	5	5
June	10	10	8	9
July	16	15	12	13
August	18	18	17	18
September	15	16	16	16
October	9	8	9	8
November	6	6	6	6
December	6	5	6	6
Annual	100	100	100	100

Mean annual evapotranspiration was calculated from evaporation and temperature data, and was estimated to be 15 inches for areas below 1000 feet elevation. Estimated mean annual evapotranspiration for higher elevations are presented in Table 7.

Table 7. Estimated Mean Annual Evapotranspiration in the Susitna River Basin

Elevation (feet)	Estimated Evapotranspiration (inches per year)
below 1,000	15
2,000	12
3,000	9
4,000	7
5,000	6
6,000	5
7,000	4
8,000 and above	3

Streamflow data are available from nine gaging stations in the basin. Data from these stations are presented in Table 8.

Table 8. Stream Gaging Stations in the Susitna River Basin

Gaging Station (location)	Drainage Area (square miles)	Mean Annual Runoff (in./yr.)	Mean Elev. (feet)
Susitna River near Denali	950	38.53	4510
MacLaren River near Paxton	280	47.34	4520
Susitna River near Cantwell	4140	20.65	3560
Susitna River near Gold Creek	6160	21.40	3420
Talkeetna River near Talkeetna	2006	27.66	3630
Chulitna River near Talkeetna	2570	46.22	3760
Little Susitna River near Palmer	61.9	44.54	3700
Skwenta River near Skwenta	2250	37.28	2810
Chuitna River near Tyonek	131	33.85	--

Streamflow data from two stations on the Nenana River (710-square-mile and 1910-square-mile drainage areas), and from stations on the Teklanika and Chakachatna Rivers, and Seattle and Caribou Creeks, were used to estimate runoff near the borders of the basin.

Gaging station records were long enough that measured average annual runoff was felt to represent long-term means. Frequency computations of individual station records indicated that mean runoff was very close to median, or 50% chance, values.

Mean annual water yield increases with increasing elevation, and is affected by topographic conditions and geographic locations. Water yield - elevation relationships were calculated for Little Susitna, Talkeetna, and Chulitna Rivers, and are presented in Tables 9, 10, and 11. Only very general estimates of water yield - elevation relationships were developed for other rivers in the basin, and these are not included here. The percentage of total water yield contributed by groundwater flow (and hence not measured by streamflow gages) was not evaluated; however, it was estimated from site conditions to be very small.

Construction of Maps

Mean annual precipitation and mean annual water yield maps were developed concurrently. Each map was necessary for developing the other, both because insufficient data were available to develop each individually, and because the

Table 9. Mean Annual Water Yield from Little Susitna River above gaging station no. 15290000

Elevation Zone	Area sq. mi.	Estimated Water Yield inches	Estimated Water Yield square mile inches
1000 to 2000	4.6	20	92
2000 to 3000	12.5	35	437
3000 to 4000	20.8	45	936
4000 to 5000	20.6	55	1,133
5000 to 6000	2.8	65	182
above 6000	0.6	70	42
Summations	61.9 sq. mi.		2,823 sq. mi. in.

Comparison with Average Annual Water Yield:

2,823 sq. mi. in. divided by 61.9 sq. mi. = 45.61 inches

Average annual water yield = 44.54 inches

Difference = 1.07 inches = +2.4% error

Table 10. Mean Annual Water Yield from Talkeetna River above gaging station no. 15292700

Elevation Zone	Area sq. mi.	Estimated Water Yield inches	Estimated Water Yield square mile inches
400 to 1000	92	13	1,196
1000 to 2000	284	15	4,260
2000 to 3000	428	20	8,560
3000 to 4000	483	24	11,592
4000 to 5000	265	34	9,010
5000 to 6000	282	42	11,844
6000 to 7000	139	50	6,950
7000 to 8000	32	60	1,920
above 8000	1	60	60
Summations	2,006 sq. mi.		55,392 sq. mi. in.

Comparison with Average Annual Water Yield:

55,392 sq. mi. in. divided by 2,006 sq. mi. = 27.61 inches

Average annual water yield = 27.66 inches

Difference = 0.05 inches = -0.2% error

Table 11. Mean Annual Water Yield from Chulitna River above gaging station no. 15292400

Elevation Zone	Area sq. mi.	Estimated Water Yield inches	Estimated Water Yield square mile inches
500 to 1000	216	25	5,400
1000 to 2000	454	32	14,528
2000 to 3000	462	39	18,018
3000 to 4000	616	47	28,952
4000 to 5000	315	53	16,695
5000 to 6000	223	61	13,603
6000 to 7000	117	68	7,956
7000 to 8000	70	75	5,250
8000 to 9000	48	82	3,936
9000 to 10000	31	85	2,635
above 10000	18	87	1,566
Summations	2,570 sq. mi.		118,539 sq. mi. in.

Comparison with Average Annual Water Yield:

118,539 sq. mi. in. divided by 2,570 sq. mi. = 46.12 inches

Average annual water yield = 46.22 inches

Difference = 0.1 inches = -0.2% error

two phenomena are closely related. (As noted earlier, precipitation equals water yield plus evapotranspiration; and water yield equals precipitation minus evapotranspiration.)

Mean annual precipitation isohyets in lowland areas were drawn on the basis of rain gage data, elevation, storm direction, and orographic effects. Data seemed sufficient to make realistic precipitation estimates up to the edges of adjoining foothills. Annual lowland water yield in inches was then computed by subtracting annual evapotranspiration from annual precipitation.

From the foothills upward, and using computed lowland values as a starting point, water yield isolines were developed from streamflow data. Water yield was assumed to be linearly related to elevation. In an iterative process, isolines based on this assumed relationship were drawn on a map and compared to measured water yields. The assumed relationship between yield and elevation was then revised, and new isolines drawn, until water yields determined from the map equaled water yields measured at appropriate stream gages. The completed water yield map was then checked by planimetering watershed areas between adjacent isolines, computing runoff volume represented by these isolines, and comparing this value to measured runoff. Mean annual precipitation isohyets were then drawn representing water yield plus estimated evapotranspiration.

Both water yield and precipitation isolines are generally related to contour lines, but this relationship is not consistent because of localized topographic, climatic, and orographic effects. Although these effects could not be quantified, they were considered subjectively during delineation of isolines.

Probable Accuracy of Estimates

Accuracy of mean annual precipitation and water yield estimates are limited by the quantity and quality of available data, and by technical difficulties involved in translating these data onto a map. For example, standard rain gages are known to catch appreciably less than the average precipitation at their locations. The discrepancy is greater during snowfall and on windy sites, and varies from one situation to another; because of these variations, no reliable correction factor is available. Mapped precipitation values for the Susitna valley south of Petersville Road were based entirely on rain gage data and are probably lower than actual values by as much as 15%.

Precipitation in mountainous areas was estimated only from watershed runoff data. Precipitation estimates at any point are subject to substantial error because distribution of runoff throughout the watershed was inferred. Values shown for elevations above 8,000 feet are especially questionable. Only a small portion of the basin exceeds 8,000 feet in elevation, and this area had little influence in computations of runoff distribution. There is no apparent basis for determining either magnitude or direction of errors in estimates, but reported values are felt to be no greater than 25% above or below actual precipitation values.

2. Soils

Soils and water constitute society's most important resources; both are essential for life on earth. While the importance of water resources is generally recognized, the importance of soils is often underrated. Nonetheless, virtually all human activities are to some degree involved with plots of different soils. Local soil conditions determine whether or not farming, ranching, forestry, recreation, waste disposal, building and road construction, wildlife management, and a host of other human activities are physically feasible.

Different kinds of soils develop in different locations. In any area, the kinds of soils formed depend on local topography, climate, geology, hydrology, organisms present, and length of soil formation.

The SCS regularly conducts soil surveys to map and analyze local soil conditions. Soil surveys identify kinds of soils present, indicate their locations in the landscape, and describe properties of each soil type (series or phase) mapped. Properties described include: soil texture, structure, porosity, plasticity, consistence, pH, organic matter content, depth, permeability, and shrink-swell potential, among others.

In addition to soil maps and data on soil properties, SCS surveys provide land-use interpretations for different kinds of soils. These interpretations are made using data on soil properties, supplemented with information on slopes, local climate, susceptibility to flooding, etc. Interpretations indicate how suitable each kind of mapped soil is for particular land uses. Land uses considered include: production of locally adapted crops and woodland products, recreation, grazing, residential settlement (e.g., can soils support building foundations or septic systems), and enhancement of wildlife. In addition, soils are evaluated in terms of selected engineering properties, e.g., which soils provide sources for sand and gravel, which provide material for construction of dikes, road beds, pond reservoirs, etc.

Because of the importance of soils to land-use planning, soil surveys provided important information for land-use analyses conducted during the Susitna River Basin study. Before the study began, three published soil surveys* described soils on about 1,242,390 acres of the study area. As part of the Susitna Basin inventories, additional soil surveys are underway. Publication of the Yentna Soil Survey, encompassing about 3,252,000 acres, is expected in the near future. Procedures for conducting soil surveys are described in detail in the National Soils Handbook (USDA SCS, 1983).

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* Soil Survey - Matanuska Valley Area, Alaska (USDA SCS, 1968).
Soil Survey - Susitna Valley Area, Alaska (USDA SCS, 1973).
Soils of the Capital Relocation Site, Alaska (USDA SCS, 1978).

3. Land Treatment and Agronomy

Because of the relatively low evapotranspiration rates in northern temperate climates, crops in Alaska use less water than similar crops growing farther south. Most of the water needs of northern crops are met by available rainfall. Some crops on some soils, however, do experience moisture stress, and suffer consequent losses in quality and yields. For these crops, appropriately applied irrigation is beneficial.

Several factors enter into determining when, how much, how, and if to irrigate. Amount and timing of both precipitation and crop water needs, along with soil capacity to store moisture, determine when and how much irrigation is needed. Topography, water availability, evaporation rate, and soil infiltration (water-intake) rate determine how irrigation water should be applied to a particular crop. Dollar values of increased crop production, compared to costs of irrigation, determine whether or not irrigation makes economic sense.

Considering these factors is important. Improperly timed or applied irrigation may be of little value to crops and a waste of money, time, and water. At worst, irrigating too much or at the wrong time may do considerable damage, as when excessive irrigation degrades water quality, leaches soil nutrients, reduces soil oxygen, or causes soil erosion.

The Susitna Basin study of land treatment and agronomy involved assessing the effectiveness of irrigating specific crops in Alaska. During the assessment, factors involved in answering the following questions were studied:

(1) Under what conditions will irrigation be beneficial?

(2) How much will crop yields be increased by irrigation?

(3) How much irrigation water should be applied?

(4) What irrigation method will work best in a particular situation?

(5) What schedule should be used in applying irrigation?

(6) What problems may irrigation cause, and how can they be avoided?

Guidelines for answering these questions were compiled in: An Irrigation Guide for Alaska (USDA SCS, in press). Users of the Guide can learn how to: recognize symptoms of moisture stress in crop plants, determine both soil moisture and net irrigation needs, and apply irrigation effectively. The Guide also indicates the variety of irrigation needs in the basin (as well as throughout other agricultural areas of Alaska).

Irrigation needs vary as a result of crop grown, soil cultivated, and local climate. For example, a farmer growing potatoes in Talkeetna on a silt loam soil with a 0.2 inch AWC[1/] would basically never need to irrigate; since natural moisture is adequate, irrigation does not improve his potato yields. On the other hand, a farmer growing grass hay near Pt. McKenzie, also on silt loam soil, would benefit by irrigating almost every year. In a wet[2/] year he would increase his hay yield by 11% if he added approximately 4.1 inches of water during the growing season. In a dry year, he could improve his hay yield by 43% if he added about 11.4 inches of irrigation water. (In both cases, the efficiency of his irrigation system is assumed to be 65%.)

By comparing the economic benefits of increased yields with the costs of installing, maintaining, and operating an irrigation system, a farmer can determine if irrigating would be cost effective. Table 12 indicates how irrigation will improve yields of three crops in two locations in the basin. The information used in preparing this table, such as AWC of agricultural soils, net irrigation needs in the basin (and state), yield response of different crops to irrigation, etc. were obtained from the Irrigation Guide.

4. Geology of the Susitna River Basin

Basin geological conditions were inventoried by the SCS using information supplied by the U.S. Geological Survey (USGS) and the Division of Geological and Geophysical Survey (DGGS) in the Department of Natural Resources. Because no new data were collected, no separate geology report was published. The synthesis, developed by Scott Sumsion for the SCS using existing data, is presented below.

The geology of the Basin is relatively complex due to regional faulting and folding of rocks in the Cook Inlet region. The region includes the Beluga, Susitna, Yentna, and Cook Inlet Basins, bordered on the east by the Talkeetna Mountains, on the west by the Aleutian Range, and on the north by the Alaska Range.

1/ AWC is the "Available water capacity" of a soil. It represents the capacity of the soil to store water available for use by plants. The AWC is usually expressed in linear depths of water per unit depth of soil, e.g., inches of water per inches of soil.

2/ For calculations in the Irrigation Guide, a "wet" season is defined as wetter than 80% of the growing seasons in a particular area, based on long-term climatological records. The wet season is also sometimes called the 20% chance season; that is, only 20% of the growing seasons will be as wet or wetter. A "dry" season is, therefore, the 80% chance season; that is 80% of the growing seasons will be as wet or wetter. The "average," or 50% chance, growing season is wetter than 50% and drier than 50% of the seasons on record.

Table 12. Irrigation Crop-yield Response

Crop	Location	20% season (wet)			50% season (average)			80% season (dry)		
		Without irrigation	With irrigation	Increase	Without irrigation	With irrigation	Increase	Without irrigation	With irrigation	Increase
Potatoes (tons)	Talkeetna	15	15	0	15	15	0	15	15	0
	Pt. McKenzie	15	15	0	15	15	0	11.6	15	3.5
Barley (bushels)	Talkeetna	52	52	0	52	52	0	44.2	52	7.8
	Pt. McKenzie	51	52	1	41.1	52	10.9	32.8	52	19.2
Grass Hay (tons)	Talkeetna	2	2	0	2	2	0	1.7	2	0.3
	Pt. McKenzie	1.8	2	0.2	1.6	2	0.4	1.4	2	0.6

The major drainage systems are the Susitna, Chulitna, Deshka, Yentna, Skwentna, Beluga, Talkeetna, and Kahiltna Rivers. The lowlands contain oil, gas, and coal bearing beds of Tertiary age. The region is generally mantled by surficial deposits of glacial and fluvial origin. Exposed bedrock ranging in age from Paleozoic through Tertiary has been identified.

The Paleozoic rocks are metamorphosed volcanic lavas and associated volcanic rocks that occur primarily in the Talkeetna Mountains in the northeastern part of the basin. Mineralized areas of copper, gold, silver, lead, and zinc occur in these rocks. Triassic and Early Jurassic sandstones and shales interbedded with volcanic flows also occur in the Talkeetna Mountains.

Mid Jurassic to late Cretaceous continental deposits of sandstone, shale, limestone, and claystone occur in the Cook Inlet Basin, and have been metamorphosed and mineralized in some areas of the Talkeetna Mountains. Associated mineralization occurs in the Alaska Range in the headwaters of the Skwentna River.

Tertiary rocks of the Kenai formation probably underlie a large portion of the basin, but have been mapped only in the western area where coal beds outcrop, and on the subsurface from oil wells south of the Castle Mountain Fault.

Abundant rock outcrops of igneous intrusives, ranging in age from Jurassic through Tertiary, occur in some parts of the basin, mostly as large granitic masses. They are found in mountainous areas to the west, north, and east, and account for some of the metamorphism that has occurred.

At least 3,500 square miles of coal-bearing rocks occur in Tertiary deposits located in the northern Cook Inlet lowlands. Beds of subbituminous coal up to 30 feet thick lie in the Beluga Basin and adjacent areas. Other coal-bearing areas include the Yentna, Susitna, and Cook Inlet Basins.

A wide variety of metallic minerals occur in lode, placer, and disseminated deposits in the mountains and foothills. Elongated belts and localized areas of these minerals are prevalent and can be related to basement faulting and related intrusions.

Oil production within the Cook Inlet region began in 1957. Seven oil fields and six gas fields are currently producing from the Kenai formation. Potential oil and gas deposits occur in the Beluga and Yentna Basins.

Much of the basin is covered with glacial moraine material ("till"), which in many places covers bedrock with deposits at least 70 feet thick. It is difficult to map the underlying geology in such areas except by seismic or gravity surveys or by well logs. The greatest interest in Tertiary deposits at this time focuses on the mineable coal deposits. The Tertiary beds have not been satisfactory as aquifers for producing large quantities of water.

The basin contains several major fault systems associated with the Shelikof Trough, which occupies the general area of Cook Inlet including the project area. Faults associated with this Trough are: the Knik-Border Ranges fault

on the south side of Cook Inlet; Bruin Bay fault, Lake Clark fault, and Castle Mountain fault on the north side of Cook Inlet (but in the south of the study area); and the Susitna and Denali faults on the north. A number of other faults in the basin have been mapped, but remain unnamed. Gravity data imply that about 12,000 feet of high angle reverse displacement occurs on the north side of the Castle Mountain fault. In addition, an estimated 10,000 feet of displacement occurs toward the southeast in the Cook Inlet Basin, and 2,500 feet in the Beluga Basin.

The fault network is believed to run parallel or obliquely to the Shelikof Trough, which developed in early Cenozoic time in southcentral Alaska. Formational contacts are often offset by large northwestward-dipping, reverse fault systems, as in the Castle Mountain - Lake Clark fault and Bruin Bay systems. There are also indications of horizontal displacement and rotational and translational deformation caused by oblique stress. These tectonic movements have resulted in a complex basement rock complex and subsequent variability in thickness of Tertiary deposits.

The active Aleutian volcanic arc ends west of the basin at Mt. Spurr volcano. Seismic discontinuity implies there is a hinge zone along the Yentna - Beluga Mountain front between the northern McKinley block, which dips northward more steeply than the Kenai block south of Cook Inlet. A subduction zone of the Pacific plate is indicated along the Aleutian trench and the Kenai block.

Mt. Spurr has potential for geothermal development, but difficulties are inherent in developing geothermal resources of an active volcano located near deep fault zones.

5. Land Cover (Vegetation)

The objective of the land cover (vegetation) inventory was to map and quantitatively describe plant communities (and other land cover types) throughout the basin. Land cover maps, once developed and automated, were used to assess vegetation-related resources in the basin, such as timber, range, wildlife habitats, and recreational areas. These assessments were, in turn, used by the state and borough in making land-use decisions.

Methods used to develop land cover maps and to conduct field sampling are briefly described below. Detailed field procedures used to inventory basin vegetation types are described in: <u>Preliminary Field Procedures for the Cooperative Vegetation Inventory of the Susitna River Basin, Alaska</u> (USFS-PNW, 1979).

Detailed descriptions of each mapped plant community (vegetation cover type), based on field data, are presented in <u>Resource Statistics for the Susitna River Basin</u> (USDA in preparation).

Land cover (vegetation) mapping was conducted using aerial photographs in conjunction with ground sampling. Initial cover-type mapping was performed on false-color infrared photography that had been enlarged from a scale of 1:120,000 to 1:60,000. On each air photo, visibly separable land areas

(polygons) were outlined, each consisting of a relatively homogeneous parcel of land at least 10 acres in size and 165 feet in width. As distinguishable polygons were outlined, each was labeled with a primary code denoting the specific land or vegetation cover type[1/] contained in that polygon. In certain instances, secondary and tertiary codes were used for polygons in which cover types occurred as complexes[2/] or associations[3/] that were impossible to map separately. Once completed, all land cover maps were rectified ("edge-matched" and scaled) to standard USGS maps at a scale of 1:63,360 and then digitized for use in computer modeling. Land cover categories used for mapping are shown on Table 13.

Statistical analysis of land cover types was accomplished using a double sampling method involving photo interpretation and ground sampling. Primary photo interpretation points were selected systematically using a grid system. The number of field plots to be sampled for each cover type was determined in part by: the number of photo points (grid intersections) occurring in that cover type; acceptable sampling error; estimates of cover-type variance based on previously completed plots; and cost. Ground sampling was done on 485 plots selected from 11,246 primary photo points.

Ground plots were sampled by multi-disciplinary crews. Use of a helicopter permitted field crews to precisely locate and then access selected grid intersection points. Plots were permanently monumented for future inventory, and resources were measured using a 10-point sample pattern. This pattern provides an inventory of a 5-acre plot on the basis of measurements made at 10 equidistant subsample points. All 10 points are located within the same vegetation type as the initial grid intersection point.

Data were collected on tree, shrub, understory, and ground cover vegetative layers, as wells as on soils and wildlife use and habitat parameters. On forested points, measurements were made of tree diameter, height, age, radial growth, and tree class. These data were compiled and analyzed to obtain tree volumes, growth, and mortality. At each of the 10 points, ground cover, total canopy cover, and vegetation under 4.5 feet in height were measured using a 2x2 foot sampling plot. Shrubs over 4.5 feet in height were sampled at 2 of the 10 points using a 10x10 foot plot. Cover, height, and annual production were estimated for each plant species in each plot.

1/ Type - (Land Cover Type) - one of 36 categories of vegetation defined by plant species composition, canopy cover, height, and/or age. In non-vegetated types, one of 10 categories, including cultural influence, mud, rock, snow, glaciers, lakes and streams.

2/ Complex - a mosaic of distinctive vegetation types. Each type is distinguishable but too small to map separately.

3/ Association - a mixture of vegetative growth forms, such as grasses, shrubs, trees, etc., that occur together naturally, but not as distinct types; typically as small visible pockets of undergrowth in open forests.

Table 13. Land Cover Mapping Units

VEGETATED			NON-VEGETATED
FOREST AND WOODLAND - more than 10% Crown Cover		NON-FOREST - less than 10% Crown Cover	
CLOSED FOREST 50% crown cover	OPEN FOREST-WOODLAND 10-50% crown cover	SALT WATER WETLANDS 50-grassland 51-low shrub 52-tidal marsh	OTHER 70-Cultural Influence 71-Tyonek Timber Sale
CONIFEROUS FOREST WHITE SPRUCE 21-short stands 30 ft. 25-tall stands 30 ft.	CONIFEROUS FOREST WHITE SPRUCE 31-short stands 30 ft. 33-tall stands 30 ft.	TALL SHRUB 60-alder 61-alder-willow (streamside veg.)	BARREN 80-mud flats 81-rock
BLACK SPRUCE 41-short stands 10 ft. 42-tall stands 10 ft.	BLACK SPRUCE 43-short stands 10 ft.	LOW SHRUB 62-willow-resin birch	PERMANENT SNOW AND ICE 82-snowfield 83-glacier
MOUNTAIN HEMLOCK 45-short stands 30 ft. 46-tall stands 30 ft.		63-GRASSLAND	WATER 91-lakes 40 ac. 92-lakes 10 ac. - 40 ac. 96-streams and rivers 165 ft. - 660 ft. wide 97-river 1/8 mile wide (660 ft.)
DECIDUOUS FOREST Closed Deciduous- Closed Mixed 22-young stands 40 yrs. 24-medium-aged stands 20-80 yrs. 26-old stands 80 yrs.	DECIDUOUS FOREST Open Deciduous- Open Mixed 32-medium-aged stands 40-80 yrs. 34-old stands 80 yrs.	TUNDRA 64-sedge-grass 65-herbaceous 66-shrub 67-mat and cushion	
COTTONWOOD 27-young stands 40 yrs. 28-medium-aged stands 40-100 yrs. 29-old stands 100 yrs.	COTTONWOOD 35-medium-aged stands 40-100 yrs. 36-old stands 100 yrs.	FRESH WATER WETLANDS 68-sphagnum bog 69-sphagnum-shrub bog	

The primary soil type was identified and a description of that soil was made at each initial sample point; additional soil descriptions were prepared if a significant change in soils, topography, or vegetation occurred within the 5-acre plot.

6. Recreation

Existing recreational resources in the basin were inventoried and mapped by DNR-Division of Parks under an agreement with the USDA. The results of that inventory are presented in Recreation Atlas - Willow-Talkeetna Basin (DNR, 1980). In addition, the SCS analyzed selected economic impacts of a wide range of basin recreational activities, and assisted the Alaska Department of Fish and Game (ADF&G) in analyzing economic impacts of basin sport fishing and hunting. The SCS analysis is discussed later in this report (Section E). The ADF&G analyses* are published in: Fish and Wildlife Resources Element for the Susitna Area Planning Study (ADF&G Habitat Division, 1984).

7. Archeological, Historical, and Cultural Resources

Three Susitna Basin cultural resource inventories and assessments** were prepared by ALASKARCTIC under contract to the USDA:

1) Cultural Resource Assessment: Talkeetna-Lower Susitna River Basin, Southcentral Alaska (G. Bacon et al., 1982)

2) Cultural Resource Assessment: Talkeetna-Lower Susitna River Basin, Southcentral Alaska (supplemental report) (G. Bacon and T. Cole, 1982) and

3) Cultural Resource Assessment: Beluga Study Area, Southcentral Alaska (G. Bacon et al., 1982).

These three assessments, plus a previous assessment conducted by D.R. Reger in the Willow Subbasin, have been published in a single document by the SCS: Susitna River Basin Study Cultural Resource Assessment of Willow-Talkeetna-Beluga Areas (USDA, 1983). Highlights of the Lower Susitna and Beluga Assessments are summarized below.

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* Appendix A, Susitna Area Plan, Human Use and Economic Effects--Sport Fishing (S.M. Burgess, 1983).

Appendix B, An Economic Analysis of Moose, Caribou, Sheep, Bear and Waterfowl Hunting in the Susitna Basin (S.M. Burgess, 1983).

** Because the Alaska Power Authority is conducting a detailed environmental assessment of the Upper Susitna area for the potential Susitna River hydroelectric project, no data were collected in the Upper Susitna Basin during this study.

Data for the Lower Susitna and Beluga cultural assessments were compiled from literature review and personal interviews, supported by limited field work. These data were generally grouped into three periods: prehistoric, ethnohistoric, and historic.

The prehistoric period predates the period covered by written records or cultural memory. Before the Susitna study, the prehistory of the study area was completely undocumented. The study synthesized available data; but no new data were uncovered. Knowledge of study area prehistory continues to be extrapolated from information gathered in adjacent areas, particularly in Interior Alaska. There, four prehistoric periods are distinguished: 1) the Tundra Period (ending circa 8,000 yrs Before Present), 2) the Early Taiga Period (circa 8,000 yrs to 4,500 yrs BP), 3) the Late Taiga Period (circa 4,500 yrs BP to AD 500), and 4) an Athapaskan Period (from approximately AD 500 to AD 1900). The prehistoric Athapaskan Period grades into the ethnohistoric period described below. The ethnohistoric period is, in turn, followed by the historic Recent Period, extending from about AD 1900 to the present.

Although no prehistoric archeological sites are known in the study area, the potential for such sites to be located appears to be quite high. The Talkeetna area, in particular, appears to be rich enough in resources to have attracted relatively dense settlement during prehistoric times, while much of the Beluga study area would appear to have been a seasonal resource zone for permanent Tanaina (Dena'ina) Athapaskan settlements located nearer to the Susitna River. Systematic field surveys are very likely to uncover prehistoric sites, particularly near rivers used by anadromous fishes, shores of lakes and ponds, margins of lowland wetlands where furbearers and migratory waterfowl are abundant, and areas through which large mammals would be naturally funneled as they moved from wintering to summer grounds. In addition, several of the "Dena'ina place names" (see below) are associated with sites that should possess some indication of past activity. Once investigated, specific sites (identified and mapped in the Talkeetna report) may add a great deal to current understanding of the Tanaina in the late prehistoric and early ethnohistoric periods.

Ethnohistoric period bridges the gap between poorly documented Alaska Native prehistory and the recent history of western civilization, and is considered to extend in time from the limit of cultural memory to the present day. During modern times, Alaskan ethnohistory becomes interwoven with the history of white settlers because, in Alaska, many native populations lived essentially aboriginal life styles well into the 20th century. Ethnohistoric data indicate the existence of a rich aboriginal history in the study area, only a fraction of which has so far been recorded. Most of the ethnohistoric data compiled for the Susitna study are contained in the annotated list of Dena'ina Place Names. The list of place names summarizes ethnogeographic data on habitation of the Susitna River drainage by the Upper Inlet Dena'ina (Tanaina) Athapaskans before contact by "white men," e.g., where the Dena'ina hunted, fished, camped, settled, etc. The data presented in the list are derived from interviews and tape recordings of Dena'ina speakers knowledgeable about Dena'ina history and folklore. Considerable additional data in the form

of recordings of folklore, music, and history, as well as additional field notes, are available, but lack of time precluded all but the most minimal references to these sources in the Susitna study reports. Annotations about geographical locations included in the published list are indexed mainly to tape recordings from the archive of Dena'ina language tapes housed at the Alaska Native Language Center, University of Alaska, Fairbanks. The bulk of recordings in this archive have not yet been transcribed or published. When they are, a much fuller picture of the aboriginal occupation of Cook Inlet will emerge. The list of Dena'ina Place Names suggested some areas to cover during the brief field survey conducted in the Talkeetna Subbasin, but field search for ethnohistoric sites indicated they will be found only through careful and systematic archeological survey.

Information on historic use of the study area by white men is relatively abundant. Material summarized in the Susitna study reports concentrated on the major activities taking place in the study area from the turn of the century to the present, including mining, trapping, hunting, trading, and the use and expansion of roads and trails. Locations of historic interest in the Talkeetna and Beluga Subbasins were compiled in a list of study area historical sites. The list identifies which sites are already listed in the Alaska Heritage Resource Survey (AHRS) file, maintained by the Office of History and Archaeology, Alaska Division of Parks, and which sites will be nominated to the AHRS file as a result of the Susitna study. In addition, many places in the study area appear to meet minimal eligibility requirements for nomination to the National Register of Historic Places, either as sites or as districts. In general, historic period sites appear relatively easy to find, but many have decayed with disuse and are no longer visible.

8. Fish, Wildlife and Wetlands

a. Fish and Wildlife

The fish and wildlife inventory work in the basin consisted of two main activities: 1) "modeling" the relative fish and wildlife values of basin lands, and 2) assisting the ADF&G in developing a methodology for creating fish and wildlife "element maps." The USDA SCS prepared a fish and wildlife report describing these two activities and summarizing selected data on: 1) species present in the basin, 2) acreages in the basin of particular kinds of habitats, and 3) human uses of basin fish and wildlife resources. Highlights of this report, Identifying Wildlife Lands: Fish and Wildlife Analyses for the Susitna River Basin Study (USDA SCS, 1984), are summarized below.

In the modeling analyses, basin habitats were evaluated in terms of: 1) their relative ability to provide food and/or cover seasonally to selected wildlife species (five species in the Willow Subbasin--moose, snowshoe hare, red squirrel, willow ptarmigan, and spruce grouse; and one species, moose, in the Talkeetna, Beluga, and Upper Susitna Subbasins); 2) their relative ability to support a variety of wildlife species ("species diversity"); and 3) their relative abundance within the basin ("habitat scarcity"). Computer maps were

produced displaying the results of each evaluation. Tables 14 and 15 provide, respectively, estimates of big game populations in the basin, and examples of "preferred" habitats for selected basin mammals. Table 16 summarizes availability of some of these habitats in terms of acres and percent-of-subbasin.

Results of each modeling analysis were integrated into one "habitat synthesis model" using steps summarized in Table 17. Results of the synthesis model were then combined with available ADF&G data to create fish and wildlife element maps for use by state planners. Element maps outline a system of basin lands that if managed for fish and wildlife would be highly suitable to maintain these resources and their human uses. The system is designed to encompass: 1) lands providing habitats for important species, such as moose, black bear, brown bear, and salmon, 2) lands supporting habitats used by a large variety of wildlife species, 3) lands that are relatively scarce in the basin or sensitive to disturbance, 4) lands serving as important access routes or harvest areas for human users of fish and wildlife, 5) lands supporting valuable wetlands, and 6) "physiographic linkages" (such as networks of water bodies, systems of wetlands, animal migration routes) that interconnect fish and wildlife habitats and maintain their ecological processes. In addition, fish and wildlife element maps subdivide identified fish and wildlife lands into four categories on the basis of general management and enhancement activities feasible in different areas. Data used and steps involved in creating fish and wildlife element maps are described in the SCS fish and wildlife report. Additional data on basin fish and wildlife and habitat resources are provided in: Fish and Wildlife Resources Element for the Susitna Area Planning Study (ADF&G Habitat Division, 1984)

b. Wetlands Mapping in the Susitna River Basin

The Susitna Basin wetlands inventory resulted in preparation and automation of wetlands maps that could be used in making land-use decisions. These wetlands maps were used in identifying key fish and wildlife lands (see discussion above), and in making other land-use decisions, e.g., in determining whether or not lands would be suitable for agriculture or settlement (see Susitna Area Plan, Public Review Draft--Summary [DNR, 1984]). Because no separate write-up accompanies the wetland maps, definitions and methods used in mapping basin wetlands are described below.

Table 14. Big game population estimates for the Susitna River Basin/Matanuska-Susitna Borough

Species	Estimated Borough Population 1/	Estimated % of State Population 2/	Preferred Habitats
moose	49,000	25-50%	Young forests, especially deciduous and mixed forests; low and tall shrublands with willow, birch, aspen, poplar, cottonwood, alder, lowbush cranberry, and other woody browse; freshwater wetlands, including muskegs, bogs, marshes; forested and shrubby stream and river valleys
brown bear	1,000	10-20%	open tundra and grasslands; but also uses a wide variety of shrub and forest habitats, especially if they are relatively open
black bear	2,000	10%	forests and woodlands; preferred areas seem to be semi-open forested areas with understory vegetation of fruit-bearing shrubs, herbs, lush grasses, and succulent forbs
Dall sheep	6,000-8,000	12-16%	steep grasslands and tundra in alpine zone characterized by cliffs, deep canyons, rock outcrops, and other types of "escape terrain"
mountain goat	300	--	alpine and subalpine areas in the Talkeetna and Chugach Mountains with grasses, sedges, and forbs; in winter, prefers rocky wind-blown ridges where forage remains accessible
wolf	800-1,000	8-13%	all habitats in which preferred prey species (e.g., moose, caribou, small game, etc.) are available

1/ Source: ADF&G. 1982. Fish and wildlife resource and public use information for Matanuska-Susitna-Beluga study area. ADF&G, Anchorage. 43 pp.

2/ Source: derived from Rearden (ed)., 1981. Alaska mammals. Alaska Geographic 8(2).

Table 15. Preferred habitats for selected Susitna Basin mammals

SELECTED SPECIES		SELECTED HABITATS	Coniferous forests (open or closed)	Deciduous forests (open or closed)	Mixed forests (open or closed)	Riparian* forests	Upland tall shrubs-alder	Riparian* tall shrubs-alder and/or willow	Upland low shrubs-willow, risin birch	Riparian* low shrubs	Herbaceous freshwater wetlands (sedge, grass)	Grasslands	Shrub tundra	Other tundra (herbaceous, mat and cushion, sedge-grass)
1.	masked shrew		X	X	X	X	X	X	X	X	X	X	X	X
2.	pika											alpine		X
3.	snowshoe hare		X	X	X	X	X	X	X	X		w/cover	X	
4.	hoary marmot											alpine		X
5.	arctic ground squirrel											alpine		X
6.	red squirrel		X		X	X								
7.	northern flying squirrel		X		X	X								
8.	beaver					X		X		X				
9.	northern red-backed vole		X	X	X	X	X	X	X	X		X	X	X
10.	muskrat					X		X		X	X			
11.	northern bog lemming		----moist----			X		X		X	X	moist		X
12.	meadow jumping mouse		----open-----			X		X		X	X	moist		
13.	porcupine		X	X	X	X								
14.	coyote		X	X	X	X	X	X	X	X	X	X	X	X
15.	grey wolf		X	X	X	X	X	X	X	X	X	X	X	X
16.	red fox		----open-----			X	X	X	X	X	X	X	X	X
17.	black bear		X	X	X	X		X	X	X	X		X	
18.	brown bear		----open-----			X		X	X	X	X	X	X	X
19.	marten		X		X	X								
20.	short-tailed weasel		----open-----			X		X		X		w/cover	X	X
21.	mink		----edges----			X		X		X	X			
22.	wolverine		X	X	X	X	X	X	X	X			X	X
23.	river otter					X		X		X	X			
24.	lynx		X	X	X	X	X	X	X	X			X	X
25.	moose		X	X	X	X	X	X	X	X	X	w/cover	X	
26.	caribou		X						X	X	X	alpine	X	X
27.	mountain goat		--in winter--				X		spring			alpine	X	X
28.	Dall sheep						near treeline		spring			alpine	X	X

* "Riparian" habitats are defined as those plant communities near enough to rivers, streams, ponds, or lakes for these water bodies to be readily accessible to mammal species in question. This distance varies with size and mobility of particular species.

Table 16. Summary of selected plant community (wildlife habitat) acreages

VEGETATION TYPES * (SCS map codes)	SUBBASINS: WILLOW 1/ acres	WILLOW 1/ % of Subbasin	TALKEETNA acres	TALKEETNA % of Subbasin	UPPER SUSITNA acres	UPPER SUSITNA % of Subbasin	BELUGA acres	BELUGA % of Subbasin
1. Open mixed forest (32,34)	276,010	28.48	57,760	2.49	11,600	.61	155,810	10.74
2. Closed mixed forest (24,26)			628,770	27.11	37,720	2.00	203,040	14.00
3. Open conifer forest (31,33)	172,010 (includes 43)	17.75	67,070	2.89	20,400	1.08	5,210	.36
4. Closed conifer forest (21,25,41,42)			153,850	6.63	17,240	.91	49,410	3.41
5. Open deciduous forest (35,36)	3,390	.35	1,740	.08	2/	2/	5,770	.40
6. Closed deciduous forest (22,27,28,29)			12,880	.56	2,720	.14	6,150	.42
7. Tall riparian shrub-alder, willow (61)	49,670	5.12	136,280	5.88	20,680	1.09	59,420	4.10
8. Tall shrubs-alder (60)			487,700	21.03	342,440	18.12	435,000	29.99
9. Low shrubs-willow, resin birch (62)	12,730 (includes 66)	1.31	13,250	.57	105,920	5.61	16,280	1.12
10. Saltwater wetlands-grass, sedge, shrub (50,51,52)	23,370	2.41	11,380	.49	0	0	18,940	1.30
11. Black spruce forests, muskegs, sphagnum bogs (43,68,69)	(43 included above; 68,69 not totaled)		528,070	22.77	5,400	.29	218,150	15.04
12. Grassland (63)	194,580	20.07	29,130	1.26	1,120	.06	25,650	1.77
13. Tundra 3/ (64,65,66,67)	145,150 (excludes 66)	14.98	68,160	2.94	1,106,960	58.58	160,250	11.05
Total vegetated acres	876,910 1/	90.47 1/	2,196,040	94.69	1,672,200	88.49	1,359,080	93.71
14. Water-lakes, streams (91,92,96,97)	92,360 1/	9.53 1/	99,830	4.30	8,280	.44	33,990	2.34
15. Non-vegetated (70,80,81,82,83)			23,380	1.01	209,240	11.07	57,350	3.95
Total acres	969,270	100.00	2,319,250	100.00	1,889,720	100.00	1,450,420	100.00

* Vegetation types are described in detail in: Resource Statistics for the Susitna River Basin (USDA in progress).

1/ Willow Subbasin plant community classes are not directly comparable to classes in other subbasins, acreages presented here are therefore rough totals.

2/ Minimum mapping unit in this subbasin was 40 acres rather than 10 acres, therefore, plant communities occurring in small scattered parcels (polygons) do not appear on the map.

3/ In Willow Subbasin, shrub tundra (SCS 66) is combined with low shrub acreage (SCS 62).

Table 17. Summary of instructions for habitat synthesis model

	Instructions for each step	SCS vegetation codes included by each step		Total acres (% of vegetated acres)* in Subbasin included by each step	
		Talkeetna-Beluga Subbasin	Upper Susitna Subbasin	Talkeetna-Beluga Subbasin	Upper Susitna Subbasin
Step 1:	map all "very scarce" and "scarce" habitats having "high species diversity" plus all "very scarce" habitats having "moderate species diversity"	31, 33, 35, 36, 50, 51, 52, 62; 22, 27, 28, 29, 43, 51, 63	24, 26, 31, 32, 33, 34, 61; 21, 22, 25, 27, 28, 29, 41, 42, 43, 63, 68, 69	225,784 (6.35%)	103,342 (6.18%)
Step 2:	map all "open mixed forests" and "tall alder-willow riparian shrublands" if not previously mapped and if not "abundant"	32, 34, 61	included by step 1	409,194 (11.51%)	included by step 1
Step 3:	map stream and river corridors	stream corridor portions of 21, 24, 25, 26, 41, 42, 60, 64, 65, 66, 67, 68, 69	stream corridor portions of 60, 64, 65, 66, 67	not computer mapped, (not computed)	not computer mapped. (not computed)
Step 4:	map all "shrub tundra" and "low shrub willow-resin birch" if not previously mapped and if not "abundant"	66	62, 66	17,470 (0.49%)	93,810 (5.61%)
Step 5:	map selected freshwater wetlands not yet mapped	SCS wetland codes 2, 3, 6	SCS wetland codes 2, 3, 6	not computer mapped, (not computed)	not computer mapped, (not computed)
	Totals			652,448 (18.35%)	197,152 (11.79%)

* 94.3% of the Talkeetna-Beluga Subbasin is vegetated.
88.5% of the Upper Susitna Subbasin is vegetated.

The wetlands inventory conducted for the Susitna Basin study represented a cooperative federal-state effort to identify, classify, and map wetlands in the basin. The following definition of wetlands was used:

> "Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water."1/

Following this general definition, land areas fitting into one of the following two categories were identified and mapped as wetlands:

1) land areas which, at least periodically, support predominantly hydrophytes2/ and in which the substrate is predominantly very poorly drained or undrained hydric soil3/; or

2) land areas which are located within an active flood plain4/; regardless of vegetation or soil conditions.

As indicated above, non-floodplain wetlands were identified and mapped by combining data on soil drainage and vegetation types. Both data sets were combined because, in Alaska, lists of hydric soils and lists of hydrophytic plants are too preliminary to be used separately.5/ Figure 5 presents the plant community-soil matrix used to identify vegetated basin wetlands.

1/ Cowardin, L.M. et al., 1979. Classification of wetlands and deepwater habitats of the United States. USFWS-OBS, Washington, D.C. 103 pp. This definition corresponds closely to the legal definition of wetlands used by the U.S. Army Corps of Engineers during its "404" wetland permit review activities: "'Wetlands' means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." (33 U.S.C. 323.2(c))

2/ hydrophyte: any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.

3/ hydric soil: soil that is wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants.

4/ active flood plain: the flood-prone lowlands and relatively flat areas adjoining inland and coastal waters including contiguous wetlands and flood plain areas of offshore islands; this will include, at a minimum, that area subject to a 1% or greater chance of flooding in any given year (100-year flood plain).

5/ In Cowardin et al. (op. cit.), the presence of either hydric soils or hydrophytic vegetation is sufficient to identify an area as a wetland.

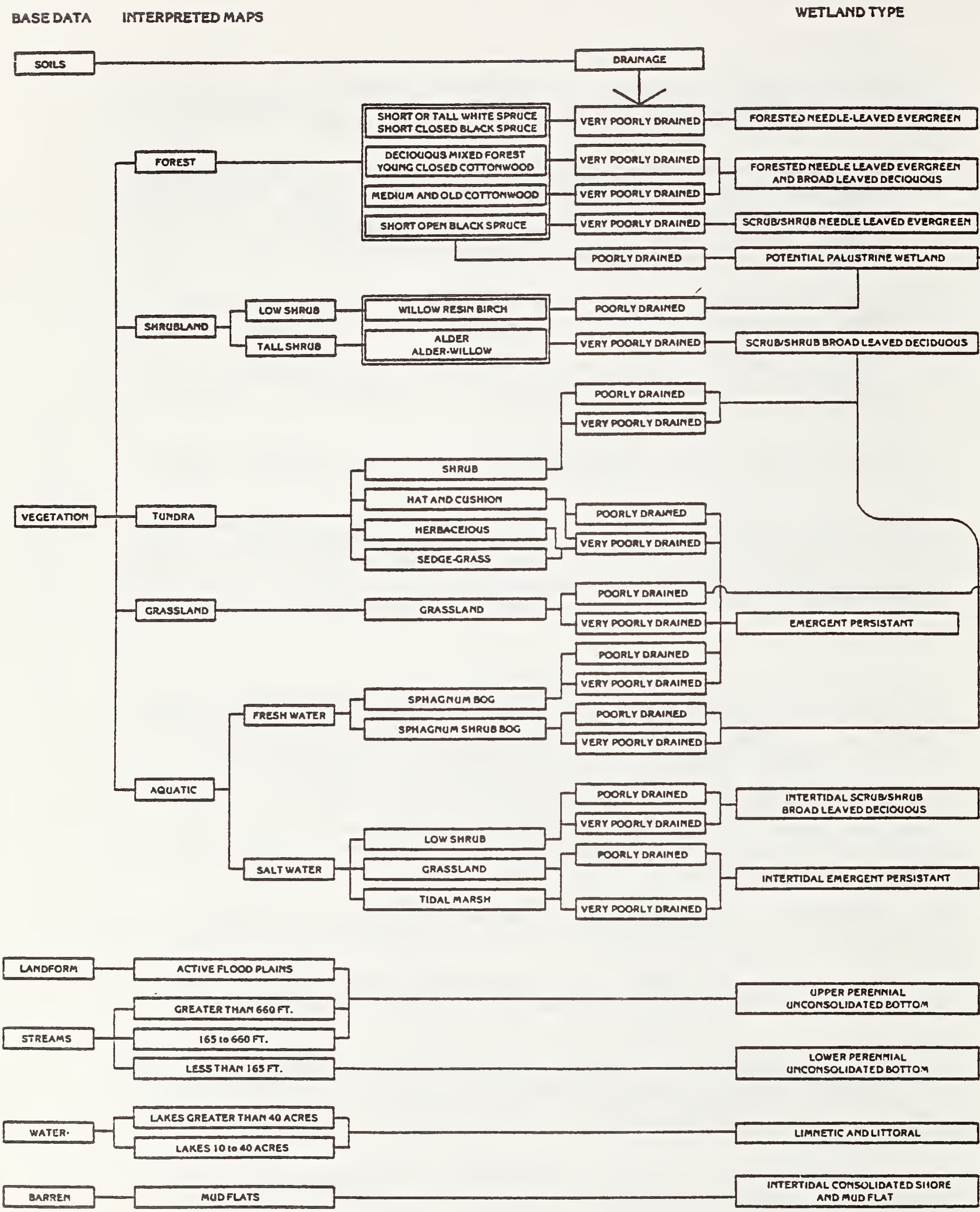

Figure 5. Wetland Identification Matrix

Identified wetlands were classified according to the system developed by the USF&WS for their on-going National Wetlands Inventory Program. Table 18 presents USF&WS vegetated wetland classes corresponding to the various vegetation-soil and vegetation-flood plain classes displayed in Figure 5. Acres and percent-of-subbasin covered by each of these classes in the Talkeetna and Beluga Subbasins are presented in Table 19.

Two limitations of this wetland identification and mapping process should be noted. First, the minimum map unit, or smallest area resolvable on wetland maps, is 10 acres. As a result, wetland areas less than 10 acres in size are not accurately delineated: wetlands 5 acres or larger may appear as 10-acre wetlands, while wetlands smaller than 5 acres may not show on the map. Second, as Figure 5 indicates, wetlands occasionally occur on "poorly" drained soils; and wetlands on these soils may not all be mapped. For example, topographic depressions can contain wetlands with "poorly" rather than "very poorly" drained soils. Field checking of poorly drained topographic depressions would be necessary to determine whether or not they produce wetland conditions.

9. Flood Plains

Five flood plain management studies were prepared during the Susitna River Basin study:

1) Flood Hazard Study, Kroto, Rabideux, Trapper, and Peters Creeks (USDA, 1982)

2) Flood Hazard Study, 196 Mile, Caswell, Sheep, Goose, Montana, Answer, and Birch Creeks and Tributaries (USDA, 1981)

3) Flood Hazard Study, Troublesome, Byers, and Honolulu Creeks; East and Middle Forks of the Chulitna River (USDA, 1981)

4) Flood Plain Management Study, Beluga Subbasin Streams (USDA, 1982)

5) Flood Plain Management Study, Kashwitna River; Wasilla, Cottonwood, and Lucile Creeks (USDA, 1982).

General methods used and results obtained during these studies are summarized below.

Flood plain studies were completed at levels of intensity commensurate with anticipated pressures for development. Flood-hazard-related topographic and field surveys were conducted at three levels of detail: (1) by using only existing USGS topographic maps, with no supplemental surveys (for streams in the Beluga area), (2) by using existing USGS topographic maps supplemented by valley cross sections (for the Talkeetna area along the Parks Highway), and (3) by preparing detailed topographic maps supplemented by valley cross sections and road and bridge surveys (for developing areas around Palmer and Wasilla).

Table 18. Classification of Wetlands in the Susitna Basin (classification after Cowardin et al. 1979)

System	Subsystem	Class*	Subclass	Dominance Type	SCS Code	USFWS Code
Palustrine: includes all nontidal wetlands dominated by trees, shrubs, persistant emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 0/00 (parts per thousand); also includes wetlands lacking such vegetation, but with all the following characteristics: 1) size less than 8 ha, 2) absence of an active wave-formed or bedrock shoreline feature, 3) water depth in the deepest part of basin less than 2 m at low water, and salinity due to ocean-derived salts less than 0.5 0/00; includes vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie; also includes the small, shallow, permanent or intermittent water bodies often called ponds.	no subsystem	Forested: includes areas in one of three SCS vegetation categories: a) closed forest, in which tree canopy cover equals or exceeds 60%; b) open forest, in which tree canopy cover equals 25-59%; and c) woodland, in which tree canopy cover equals 10-24% (trees are defined by SCS as "woody plants having one well-developed stem and usually more than 12 ft. in height.")	Needle-leaved evergreen: predominant woody life form is needle-leaved evergreen	Picea mariana: black spruce constitutes the dominant subclass species	1	PF04
			Broad-leaved deciduous: predominant woody life form is broad-leaved deciduous	Populus balsamifera: cottonwood (balsam popular) constitutes the dominant subclass species	2	PF01
			Needle-leaved evergreen and Broad-leaved deciduous: these two woody life forms are co-dominant		3	PF04-PF01
		Scrub-shrub: includes areas dominated by woody vegetation less than 12 ft. tall; species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions; tree canopy cover is less than 10%, shrub cover equals or exceeds 25%	Needle-leaved evergreen: predominant woody life form under 12 ft. tall is needle-leaved evergreen	Picea mariana: black spruce constitutes the dominant subclass species	4	PSS4
			Broad-leaved deciduous: predominant woody life form under 12 ft. tall is broad-leaved deciduous		5	PSS1
		Emergent: includes areas dominated by erect, rooted, herbaceous hydrophytes; this vegetation is present for most of the growing season in most years; tree canopy cover is less than 10%, shrub cover less than 25%	Persistent: dominated by species that normally remain standing at least until the beginning of the next growing season		6	PEM1
Estaurine: includes deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land; the salinity may be periodically increased above that of the open ocean by evaporation.	Intertidal: substrate is exposed and flooded by tides; includes the associated splash zones	Scrub-shrub: (see Palustrine, Scrub-shrub)	Broad-leaved deciduous: (see Palustrine, Scrub-shrub, Broad-leaved deciduous)	Myrica: sweetgale or other broad-leaved deciduous shrubs constitute the dominant subclass species	11	E2SS1
		Emergent: (see Palustrine, Emergent)	Persistent: (see Palustrine, Emergent, Persistent)	Elymus, Calamagrostis: grasses constitute the dominant subclass species	12	E2EM1
				Scirpus, Carex, etc.: emergent persistent wetlands dominated by rushes, sedges, or other forbs	13	E2EM1
		Flat: includes all wetlands having three characteristics: (1) unconsolidated substrates with less than 75% areal cover of stones, boulders, or bedrock; (2) less than 30% areal cover of vegetation other than pioneering plants; and (3) any appropriate water regime (e.g. regularly flooded)	Mud: the unconsolidated particles smaller than stones are predominantly silt and clay; anaerobic conditions often exist below the surface		14	E2FL3

* SCS definitions of vegetation classes coincide with Viereck and Dyrness (1980), definitions of non-vegetation classes coincide with Cowardin et. al. (1979).

Table 19. Wetland Types, Susitna River Basin[1/]

	Talkeetna Acres	%	Beluga Acres	%
Forested Needle Leaved Evergreen	40,920	1.76	20,480	1.41
Forested Needle Leaved Evergreen and Broad Leaved Deciduous	14,790	0.68	9,530	0.65
Scrub/shrub Needle Leaved Evergreen and Broad Leaved Deciduous	453,700	19.56	189,770	13.08
Emergent Persistant	70,890	3.06	107,670	7.42
Potential Palustrine Wetland Inclusions	140,400	6.05	65,670	4.53
Intertidal Scrub/shrub Broad Leaved Deciduous	2,510	0.11	10,790	0.12
Intertidal Emergent Persistant (Calamagrostis)	4,110	0.18	9,250	0.64
Intertidal Emergent Persistant	4,760	0.21	7,900	0.54
Intertidal Unconsolidated Shore Mud Flat	8,110	0.35	10,540	0.73
Upper Perennial Riverine	232,000	10.00	0	0.00
Littoral and Limnetic	91,010	3.92	33,990	2.34
Non Wetland	1,256,050	54.16	993,830	68.52
Totals	2,319,250	100.04[2/]	1,459,420	99.98[2/]

1/ Data are presented for Talkeetna and Beluga Subbasins only. Data collected for the Upper Susitna Subbasin are not in sufficient detail to permit assignment to these categories.

2/ Totals do not add to 100.00 due to rounding.

Hydraulics

Elevation-discharge relationships were developed using the topographic and field survey data referred to above. For Beluga area streams, elevation-discharge relationships were developed for valley sections assuming normal flow and using Manning's flow equation*. Hydraulic parameters existing prior to 1981, i.e. pre-1981 physical characteristics of the channel and flood plain, were used in the computations. High water marks, stream gage records, and other historical flood data were used to test the accuracy of computed water surfaces.

Three stream gages are located in the study area. Records from only one, on the Skwentna River near Skwentna, are adequate for peak-frequency (percent chance of high water) analysis. The Chakachatna River gage near Tyonek is at the mouth of Chakachamna Lake and, therefore, is not representative of peak discharge from the area; and data from the Chuitna River gage near Beluga are too limited (covering only 1975-1981) for development of reliable peak-frequency curves. For these reasons, the latter two gages were used only to help in identifying historical high water marks. For Parks Highway streams and Palmer-Wasilla area studies, elevation-discharge relationships were developed for all bridges, culverts, and valley sections utilizing the Water Surface Profile computer program (WSP2) outlined in SCS Technical Release No. 61 (USDA, 1976). Hydraulic parameters of the channel and flood plain for conditions prior to 1979 were used as input data for the WSP2 program. High water marks, stream gage records, and other historical flood data were used in checking the accuracy of the computed water surface profiles. Two stream gages were located in these study areas, one on Cottonwood Creek and one on Montana Creek, each with short periods of records (less than 10 years). These records were utilized to help determine the accuracy of the computed hydraulics.

Hydrology

Annual-peak-discharge studies have been made by the USGS for all of Alaska. The USGS has published a regional analysis, "Flood Characteristics of Alaskan Streams" (Water Resources Investigations 78-129, 1979), that presents regional equations for determining peak discharges in two areas in Alaska, Area I and Area II. This river basin study is located in Area II. Curves showing the frequency or percent chance of high water (peak-frequency curves) were, therefore, developed by using both the equation proposed by USGS and the Log-Pearson Type III method. High water (peaks) calculated by these two methods for given frequency storms were compared to determine the adequacy of the regional equation for this study. These comparisons indicated that the regional equation was adequate for the relatively flat lowland areas of Wasilla, Cottonwood, and Lucile Creeks; however, for Kashwitna River and Parks Highway streams, Peters Creek, and Beluga streams, the regional equation

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* Manning's equation is used to calculate stream flows given existing channel characteristics.

was determined to be inadequate. As a result, stream gage records within the Southcentral Region were used to develop peak-frequency curves in an effort to obtain more reliable peaks for the study area.

A range (upper and lower curves) for high, medium, and low peak discharges for the 2-year, 10-year, 50-year, 100-year and 500-year events was developed. (See Appendix E, Exhibits 5, 6, 7, 8, and 9 of the "Flood Hazard Study for 196 Mile, Caswell, Sheep, Goose, Montana, Answer, and Birch Creeks" by SCS, 1981.) These curves, and watershed characteristics such as watershed slope, channel length and slope, mean elevation, land cover, and average annual precipitation, were used to develop a curve showing the frequency of peak-discharges produced by the events mentioned above for each watershed at each cross section.

Cottonwood and Lucille Creeks both run through lakes for long distances. Discharges at the outlets of the lakes were found to control water surface elevations downstream from the outlets. Peak discharges were determined at the lake outlets; from that point downstream, watershed areas above the lake outlets were considered noncontributing to the stream stage.

The peak discharges of the 10-, 50-, 100-, and 500-year storm events for each watershed area above each cross section were determined from the curves described above and then used to determine water surface elevations and area inundated on each stream. The area inundated by the 100-year frequency event was outlined on flood plain maps as a part of each study. Table 20 provides a list of streams studied in the basin, and for each, indicates area subject to flooding from the 100-year frequency event.

The major areas studied are shown on Figure 6. In addition to the information provided above, all reports contain maps showing the potential areas of inundation, as well as information on historical floods and flood damage potential.

Table 20. Streams Studied in the Susitna River Basin, and Areas of Each Subject to Flooding (100-year flood plain)

196 Mile Group

Stream	Area Subject to Flooding (acres)
196 Mile Creek	400
Caswell	850
Sheep Creek	3,450
Goose Creek	570
Montana Creek	1,480
Answer Creek	140
Birch Creek	80
Total	6,970

Chulitna Group

Stream	Area Subject to Flooding (acres)
Troublesome Creek	20
Byers Creek	40
Honolulu Creek	60
East Fork of Chulitna River	840
Middle Fork of Chulitna River	1700
Total	2,660

Kroto Group

Stream	Area Subject to Flooding (acres)
Kroto Creek	2,880
Moose Creek	4,780
Ninemile Creek	620
Gate Creek	280
Twentymile Creek	100
Seventeenmile Creek	80
Peters Creek	600
Kenny Creek	120
Rabideux Creek	570
Trapper Creek	2,770
Total	12,800

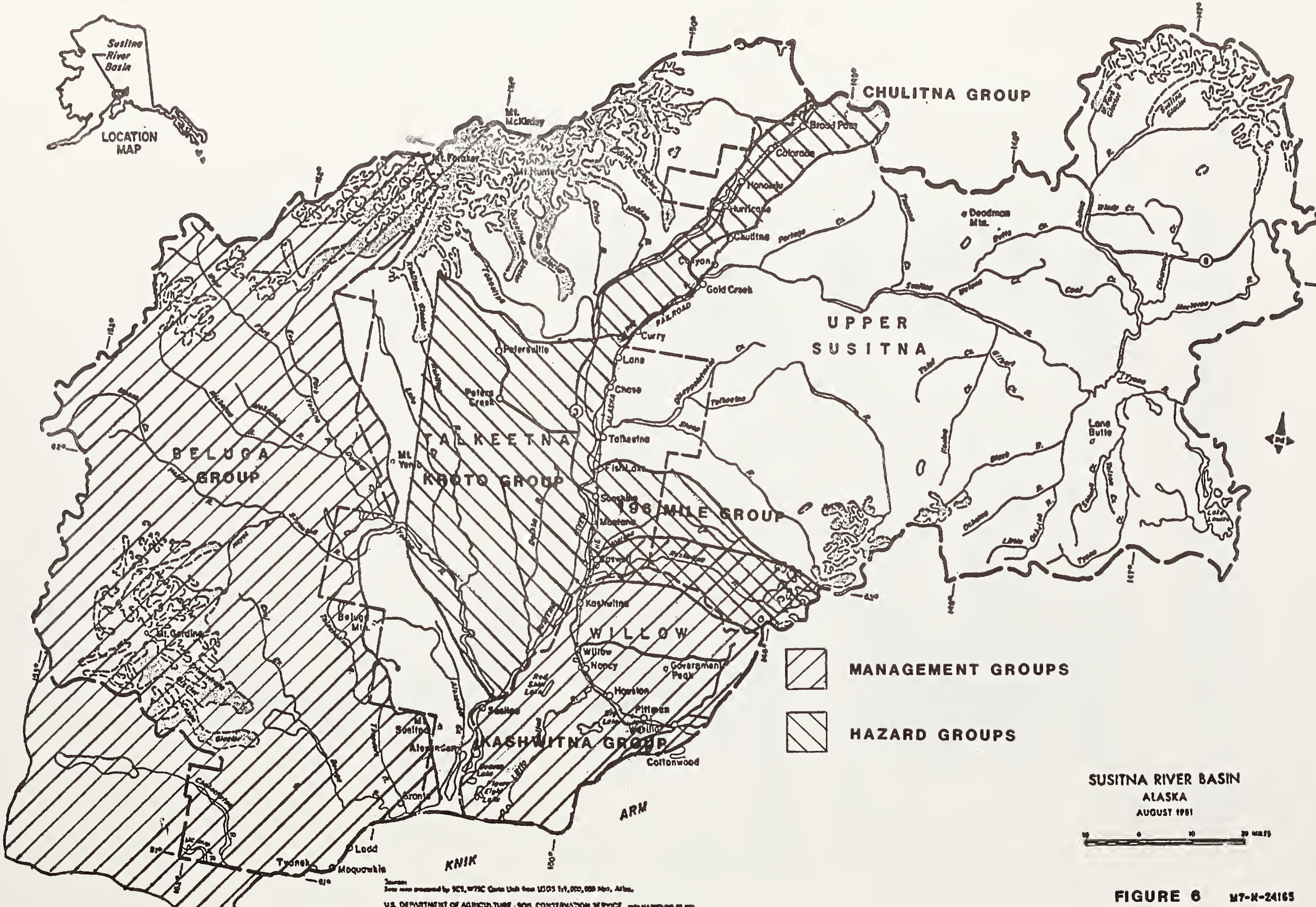
Table 20. Streams Studied in the Susitna River Basin, and Areas of Each Subject to Flooding (100-year flood plain) (continued)

Beluga Group

Stream	Area Subject to Flooding (acres)
Kustatan River	51,800
McArthur, Chakachatna, and Chuitkinachna Rivers	87,700
Old Tyonek Creek	1,000
Tyonek Creek	900
Chuitna River	2,200
Beluga, Theodore, and Lewis Rivers	23,000
Yentna and Tributaries	140,000
Total	306,600

Kashwitna Group

Stream	Area Subject to Flooding (acres)
Kashwitna River	1,050
Wasilla Creek	310
Cottonwood Creek	170
Lucile Creek	240
Total	1,770



SUSITNA RIVER BASIN
ALASKA
AUGUST 1981

FIGURE 6 M7-K-24165

E. Objective: Identify the economic value of selected recreational resources within the basin.

Rationale: To increase public awareness of the economic values associated with recreational resources and thus provide an indication of economic trade-offs that would result from selected changes in land-use, e.g., converting existing recreational lands to, for example, settlement lands.

Analysis: Nine[1/] recreational activities were examined basin-wide. Those activities were:

- Small game hunting
- Waterfowl hunting
- Kayaking/Canoeing
- Cross-country skiing
- Snowmobiling
- Hiking with pack
- Picnicking
- Tent camping
- Recreational vehicle camping

For each activity, estimates were made of demand from and economic value[2/] to recreational participants from four points of origin: 1) Anchorage, 2) Fairbanks, 3) the Mat-Su Borough, and 4) outside Alaska (nonresidents).

Levels of demand from within Alaska were estimated based on participation rates presented in DNR's 1981 Alaska Outdoor Recreation Plan, while nonresident demand levels were derived from the 1977 Visitor Expenditure Survey commissioned by the Alaska Department of Commerce and Economic Development.

Recreational values were estimated using the travel cost method (TCM). The TCM assumes that the value of a recreational activity is equal to the sum of the round trip costs incurred by participants in gaining access to recreational sites. Resident travel costs used in this study include only variable costs for auto/truck travel, and both variable and fixed costs for Recreational Vehicle travel. For nonresidents, costs for round trip transportation to Alaska, as well as lodging and special license fees (where applicable), have also been included.

1/ The Alaska Department of Fish and Game conducted similar analyses for freshwater fishing and big game hunting (see references cited under recreation inventory). The USDA assisted ADF&G with portions of this work.

2/ In this case economic value is limited to transportation costs discussed on the following page.

All human use figures in the analysis are expressed as user days. A user day is any portion of a 24-hour period in which an individual (user) participates in a particular recreational activity. (A person who camps overnight, picnics, and then hikes a scenic trail during one 24-hour period has completed 3 user days, one for each activity.) In the travel cost method, monetary user-day values for any recreational activity increase as users travel farther to engage in that activity. In order to take this distance factor into account, monetary values of each recreational activity were computed based on both distances traveled to reach that activity and number of users traveling those distances. Concentric travel-time zones (each representing 1 hour of travel, or 45 miles), were drawn radiating out from cities within and outside the basin. User-day values could then be computed for all activities within each zone by estimating how many users recreated within that zone and how far that zone was from users' points-of-origin.

Table 21 presents total user days in all zones (hourly driving intervals) that fall within basin boundaries. This table also converts use into facility demand based on composite factors set forth in Table 22.

Results: Table 23 summarizes the economic value of each selected recreational activity within the planning area. Values estimated represent only a portion of the total value of fish and wildlife and recreational resources. Even though the analyses conducted by ADF&G on freshwater fishing and big game hunting will yield values additional to those of the nine activities examined here, the total estimated value for all analyzed recreational activities will still fall short of the actual total value of recreational resources for two major reasons:

1) Many activities have not been considered, and

2) Many other expenses, e.g. gear, more costly alternative travel modes, etc., have not been included.

In addition to the demand and value analysis described above, an attempt was made to determine unit values of meat and fish harvested. These values are presented in Table 24 and have been utilized in part by ADF&G for estimating basinwide total harvest values. It should be noted that for a significant portion of the population, unit values in tables 23 and 24 would be additive.

F. Objective: Develop an integrated automatic data processing capability to handle collected resource data. Use data processing capability to evaluate and select land uses for the Susitna Basin.

Rationale: Early in the Susitna Basin study, it became apparent that analyzing the large volume of land-based geographic information being collected would require the use of computers. As a result, a data processing system was developed to handle analysis of river basin data, and to facilitate the use of basin data for making land-use decisions.

Table 21. Existing Recreational Demand[1/]

	Annual User Day Demand	Facility Demand (Peak Day)[2/]	
	Total	Facility Units	Total
Kayaking/Canoeing	70,524	stream miles	88.2
Cross-country skiing	99,585	trail miles	92.6
Snowmobiling	95,341	trail miles	59.5
Hiking	74,713	trail miles	62.3
Picnicking	376,987	sites	502
Rec. vehicle camping	120,064	sites	832
Tent camping	107,371	sites	447
Waterfowl hunting	19,065	Not Available	
Small game hunting	44,068	Not Available	

1/ Includes Residents and Non-Residents.

2/ A peak day is defined as that day in which maximum daily use occurs.

Table 22. Standards for selected recreational activities

1	2	3	4	5
Activity	% of 1/ total annual demand occurring on peak day	% of 1/ total annual demand requiring facilities	Facilities 1/ required per demand day	Composite factor (facilities required per user day) (2 x 3 x 4) 8/
Stream Fishing	1.56	100 3/	.0126 mi 5/	.000197
Lake Fishing	1.56	50 4/	.053 units 6/	.000413
Kayaking/Canoeing	2.5	75	.0667 mi	.001251
Cross-country Skiing	1.55	90	.0667 mi	.000930
Snowmobiling	1.04	90	.0667 mi	.000624
Hiking	2.5	50	.0667 mi	.000834
Picnicking	1.88	52	.136 units	.001330
RV Camping	2.5	100	.277 units	.006925
Tent Camping	2.5 2/	50 4/	.333 units 7/	.004163

1/ Derived from Alaska Outdoor Recreation Plan (1976-1980), Alaska Division of Parks.

2/ Assumed to be same as hiking.

3/ Since facilities in this case are in terms of stream miles, all users require facilities.

4/ No data available - this is an SCS estimate - assumed same as hiking.

5/ Estimated by SCS as follows:
100'/person 1.5 turnover = 66.67' person/day 66.67' = .0126 miles.

6/ Estimated by SCS as follows: 1 ramp accommodates 5 veh. plus trailers; day capacity = 5 veh. x 2.5 persons/veh. x 1.5 turnover = 18.75 persons; 1 person needs 1/18.75 ramps = .053 ramps (units).

7/ Estimated by SCS as follows:
3 persons/site 1 ÷ 3 = .333 sites/person.

8/ The product of these factors and demand equals total facilities required.

Table 23. Existing Recreational Value
Susitna Planning Area Excluding Willow Subbasin
(1982 Dollars)

Activity	Total Annual Recreation Value to Residents	Total Annual Recreation Value to Non-Residents	Total Annual Value	Total Present Value 1/
Kayaking/ Canoeing	1,682,620	143,539	1,826,159	18,106,000
Cross-country Skiing	897,300	195,472	1,092,772	10,834,600
Snowmobiling	2,958,362	235,047	3,193,409	31,662,000
Hiking	588,780	124,825	713,605	7,075,300
Picnicking	3,696,140	3,055,223	6,751,363	66,938,500
Rec. Vehicle Camping	676,940	4,649,081	5,326,021	52,806,500
Tent Camping	837,540	627,078	1,464,618	14,521,400
Waterfowl Hunting	507,180	45,537	552,717	5,480,100
Small Game	1,240,391	97,660	1,338,051	13,266,500

1/ Based on 50 year evaluation period, 10% discount rate.

Table 24. Fish and Game Protein Values 1/

Food Item	Value/lb. (2nd quarter 1982 projected price base)
Black Bear	3.16
Beaver	4.21
Caribou	4.21
Duck (Eider)	3.16
Moose	4.21
Reindeer	3.16
Salmon (wet weight)	
Chinook	4.12
Chum	4.52
Coho	4.37
Pink	4.31
Sockeye	4.27

1/ Values were based on average costs of obtaining comparable amounts of protein from 23 specified meats and meat alternatives. These 23 items are as follows:

Peanut butter
Bread, white enriched
Dry beans
Eggs, large
Chicken, ready-to-cook
Bean soup, canned
Milk, whole, fluid
Ground beef
Chicken breasts halves
Beef liver
Tuna, canned
Turkey, ready-to-cook
Processed American cheese
Cured ham
Round beefsteak, bone in
Ocean perch fillet, frozen
Frankfurters
Chuck roast of beef, bone in
Rump roast of beef, boned
Pork chops, center
Bologna
Bacon, sliced
Porterhouse beefsteak

Analysis: Once the need for computer processing of basin data was recognized, a computer contractor (Environmental Systems Research Institute, Redlands, California) was selected to work with study participants in automating and analyzing basin data. Working with state and federal resource specialists and planners, ESRI rectified, digitized, and automated all available land-based data for the Talkeetna, Beluga, and Upper Susitna Subbasins. In addition, agency and ESRI personnel together developed computer "models" for analyzing automated data. Models were designed to assess natural opportunities for and constraints on implementing different land uses throughout the basin, based on inventoried environmental conditions. Results of model analyses were presented on computer-generated maps that showed basin lands rated in terms of their suitability to support different land uses.

Computer models were based on land suitability "criteria" selected by resource specialists and land planners. Criteria reflected the assumed effects of particular mapped environmental conditions upon particular land uses. For example, "slope" represented one mapped environmental condition that affected the use of land for settlement. It was assumed that slopes exceeding 30% would be "unsuitable" for settlement because of the potential difficulties of clearing and building on such slopes, and because of the potential damages (erosion, mass wasting) that development on such slopes could cause. "Slope percent," therefore, became one land suitability criterion in the settlement "model." Likewise, certain vegetation types were assumed to be conducive to "remote large lot" settlement because they could provide timber for house logs and/or firewood; so the presence of such vegetation types became a suitability criterion in the "remote settlement" model.

All computer suitability models were based on automated environmental data; however, some analyses were based directly on the field data, while others were based on additional interpretations of those data. Development of suitability models, and criteria used in each, are described in detail in: Final Report Computerized Geographic Information System, Talkeetna and Beluga Subbasins, Susitna River Basin, Alaska (ESRI, 1982). In addition, examples of suitability models are presented in Appendix D.

Results: Data processing was essential in developing land-use plans for state and borough lands in the Susitna Basin. Alternative land use plans developed using data processing methods outlined above are described in "elements" prepared by DNR and ADF&G with USDA input. These elements have been published by DNR, one element for each land use: agriculture, fish and wildlife, forestry, recreation, settlement, subsurface resources, and transportation. The final proposed land use plan for the basin, developed by the state and borough through a process of negotiating and balancing trade-offs among potentially suitable land uses, and involving considerable public input and review, is presented in: Susitna Area Plan Public Review Draft - Summary (DNR, 1984).

APPENDICES

III. Appendices

APPENDIX A

Supplementary Reports

Prepared by or for the USDA:

(Those marked with an * are contained in full in: Susitna River Basin Study Summary of USDA Investigations and Analyses [USDA SCS, 1985])

Economics:

1. The Susitna Cooperative River Basin Study Economic Development Analysis (P. Fuglestad and J. O'Neill, 1983, USDA ERS, SCS)

2. * A Methodology for Estimating Road Costs in the Susitna River Basin (P. Fuglestad and J. O'Neill, 1983, USDA ERS, SCS)

Water Resources:

1. * Mean Annual Precipitation and Water Yield in the Susitna River Basin (E. Merrell, 1979, USDA SCS)

2. Susitna Basin Planning Background Report - Water Supply and Demand (B. Loeffler, 1980, ADNR in cooperation with USDA)

3. Susitna Basin Water Quality Report (B. Rummell, no date, for USDA SCS, FS, ERS)

Soils:

1. Soil Survey - Susitna East Area, Alaska (USDA SCS, in progress)

2. Soil Survey - Yenta Area, Alaska (USDA SCS, in progress)

Land Treatment and Agronomy:

1. Alaska Irrigation Guide (E. Merrell, in progress, USDA SCS)

Geology:

1. Geology Report for the Talkeetna Subbasin, Susitna River Basin Alaska Cooperative Study (S. Sumsion, 1979, unpublished report prepared for the USDA SCS)

Land Cover (Vegetation):

1. Preliminary Field Procedures for the Cooperative Vegetation Inventory of the Susitna River Basin, Alaska (USDA FS, PNW, 1979)

2. Resource Statistics for the Susitna River Basin (C. Steele, SCS FSL, W. Watts, USDA SCS, in progress)

3. Timber Resource Statistics for the Talkeetna Block, Susitna River Basin Multiresource Inventory Unit, Alaska (T. Setzer, G. L. Carroll, B. R. Mead, 1979, USDA FS, PNW Forest and Range Experiment Station)

Recreation:

1. Recreation Atlas - Willow-Talkeetna Basin (ADNR in cooperation with USDA, 1979)

Archeological, Historical, and Cultural Resources:

1. Cultural Resource Assessment: Talkeetna-Lower Susitna River Basin, Southcentral Alaska (G. Bacon, J. Kari, and T. Cole, 1982, for USDA SCS, FS, ERS)

2. Cultural Resource Assessment: Talkeetna-Lower Susitna River Basin, Southcentral Alaska (supplemental report) (G. Bacon and T. Cole, 1982, for USDA SCS, FS, ERS)

3. Cultural Resource Assessment: Beluga Study Area, Southcentral Alaska (G. Bacon, J. Kari, T. Cole, C. Mobley, and R. Carlson, for USDA SCS, FS, ERS)

Fish and Wildlife and Wetlands:

1. Identifying Wildlife Lands: Fish and Wildlife Analyses for the Susitna River Basin Study (D. Lehner, 1984, USDA SCS)

2. * Wetlands Mapping in the Susitna River Basin (USDA SCS, 1984)

Flood Plain Management:

1. Flood Hazard Study, 196 Mile, Caswell, Sheep, Goose, Montana, Answer, and Birch Creeks and Tributaries (E. Grey, 1981, USDA SCS)

2. Flood Plain Management Study, Beluga Streams (E. Grey, 1982, USDA SCS)

3. Flood Plain Management Study, Kashwitna River; Wasilla, Cottonwood, and Lucile Creeks (E. Grey, 1982, USDA SCS)

4. Flood Hazard Study, Kroto, Rabideux, Trapper, and Peters Creek (E. Grey, 1982, USDA SCS)

5. Flood Hazard Study, Troublesome, Byers, and Honolulu Creeks; East and Middle Forks of the Chulitna (E. Grey, 1981, USDA SCS)

Data Processing (Geographic Information Systems):

1. Final Report: Computerized Geographic Information System - Talkeetna and Beluga Subbasins, Susitna River Basin, Alaska (ESRI, 1982, for USDA SCS, FS)

2. Final Report: Computerized Geographic Information System - Upper Susitna Subbasin (ESRI, 1983, for USDA SCS, FS)

Bibliographies:

1. Susitna River Basin Resource Bibliography (ADNR in cooperation with USDA, 1977)

2. Susitna River Basin Resource Bibliography, supplement 1979 (D. Lockhart, 1979, ADNR in cooperation with USDA SCS, FS, ERS)

Prepared by other agencies with USDA assistance:

1. Land Status Atlas - Susitna River Basin (Alaska Department of Natural Resources, 1978)

2. Land Use Issues and Preliminary Resource Inventory (volume 1 of 2) Growth Potential, Development Issues, Settlement Patterns (volume 2 of 2) (Alaska Department of Natural Resources, in cooperation with the Matanuska-Susitna Borough, Alaska Department of Fish and Game, Alaska Department of Transportation and Public Facilities, Kenai Peninsula Borough, and USDA, 1982)

3. Matanuska-Susitna Borough Comprehensive Plan (Matanuska-Susitna Borough)

4. Resource Elements (Department of Natural Resources, 1984)

   a. Agriculture Element for the Susitna Area Plan

   b. Fish and Wildlife Resources Element for the Susitna Area Plan (Alaska Department of Fish and Game)

   c. Forestry Element for the Susitna Area Plan

   d. Settlement Element for the Susitna Area Plan

   e. Recreation Element for the Susitna Area Plan

   f. Subsurface Resources Element for the Susitna Area Plan

5. Response to Public Comments on the Draft Susitna Area Plan (Alaska Department of Natural Resources, 1985)

6. Susitna Area Plan (Public Review Draft) (Alaska Department of Natural Resources, in cooperation with the Matanuska-Susitna Borough, Alaska Department of Fish and Game, Alaska Department of Transportation and Public Facilities, Kenai Peninsula Borough, USDA, and BLM, 1984)

7. Susitna Area Plan (Final Draft) (Alaska Department of Natural Resources, in cooperation with the Matanuska-Susitna Borough, Alaska Department of Fish and Game, Alaska Department of Transportation and Public Facilities, Kenai Peninsula Borough, USDA, and BLM, 1985)

8. Susitna Area Plan Land Use Alternatives (Alaska Department of Natural Resources, 1983)

9. Susitna Area Plan, Public Workshops Spring 1983, Summary of Results and Staff Analysis (Alaska Department of Natural Resources, Resource Allocation Section, Division of Land and Water Management, 1983)

10. A Synthesis and Evaluation of ADF&G Fish and Wildlife Resources Information for the Willow and Talkeetna Subbasins (Alaska Department of Fish and Game, 1983)

APPENDIX B

Linear Programming Assumptions and Results

Table B-1 identifies those assumptions (parameters) used in developing each of the agriculture/timber development alternatives. Table B-2 presents the results of each of those alternatives. Assumptions used were provided by the Alaska Department of Natural Resources.

The Talkeetna mathematical programming model is a modification of the Willow Subbasin model (Fuglestad). While several differences exist between the models because of a change in study direction and emphasis, the two models share a common philosophy in terms of their objective and structure. The objective of both is to maximize the present value of net benefits of timber and agricultural development in the study area. The model was used to run the 25 alternative analyses.

The model maximizes net benefits subject to limitations of land, timber, and accessibility.

Unless otherwise noted all benefits and costs are on a 1983 price base.

Table B-1. Alternative Parameters

Parameters	Unit	Alternatives 1	2	3	4
50-year analysis period	(beginning and ending)	0-50	0-50	20-70	20-70
Discount rate	(%)	7 5/8	10	7 5/8	10
Road costs:					
Overhead	(% of construction cost)	35	35	35	35
O&M	(% of construction cost)	1	1	1	1
Timber/ag cost share[1/]	(%)	100	100	100	100
Clearing cost	($/ac)	300.00	300.00	300.00	300.00
Production cost:					
Barley - Class II land	($/ac)	146.69	146.69	146.69	146.69
Barley - Class III land	($/ac)	146.69	146.69	146.69	146.69
Logging	($/hr)	97.24	97.24	97.24	97.24
Overhead:					
Barley	(%)	20	20	20	20
Logging	(%)	20	20	20	20
Barley yield:					
Class II land	(bu/ac)	50	52.5	52.5	52.5
Class III land	(bu/ac)	50	47.5	47.5	47.5
Timber volume	(ft^3/ac)	1,246	1,246	1,246	1,246
Logging productivity	(ft^3/hr)	283.9	283.9	283.9	283.9
Prices:					
Barley	($/bu)	3.12	3.12	3.12	3.12
Spruce logs	($/MBF)	160.00	160.00	160.00	160.00
Cottonwood	($/MBF)	125.00	125.00	125.00	125.00
Fuelwood	($/cord)	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	(MBF/yr)	6,600	6,600	23,400	23,400
Fuelwood	(cords/yr)	11,000	11,000	37,500	37,500
Barley	(mmbu/yr)	57.5	57.5	57.5	57.5

1/ portion of total road cost allocated to timber and agriculture development.

Table B-1. Alternative Parameters (continued)

Parameters	Unit	Alternatives 5	6	7	8
50-year analysis period	(beginning and ending)	20-70	20-70	0-50	0-50
Discount rate	(%)	7 5/8	10	7 5/8	7 5/8
Road costs:					
Overhead	(% of construction cost)	35	35	35	35
O&M	(% of construction cost)	1	1	1	1
Timber/ag cost share[1/]	(%)	100	100	100	10
Clearing cost	($/ac)	300.00	300.00	300.00	300.00
Production cost:					
Barley - Class II land	($/ac)	146.69	146.69	146.69	146.69
Barley - Class III land	($/ac)	146.69	146.69	146.69	146.69
Logging	($/hr)	97.24	97.24	97.24	97.24
Overhead:					
Barley	(%)	20	20	20	20
Logging	(%)	20	20	20	20
Barley yield:					
Class II land	(bu/ac)	52.5	52.5	52.5	52.5
Class III land	(bu/ac)	47.5	47.5	47.5	47.5
Timber volume	(ft^3/ac)	1,246	1,246	1,246	1,246
Logging productivity	(ft^3/hr)	283.9	283.9	283.9	283.9
Prices:					
Barley	($/bu)	3.96	3.96	3.96	3.96
Spruce logs	($/MBF)	160.00	160.00	160.00	160.00
Cottonwood	($/MBF)	125.00	125.00	125.00	125.00
Fuelwood	($/cord)	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	(MBF/yr)	23,400	23,400	6,600	6,600
Fuelwood	(cords/yr)	37,500	37,500	11,000	11,000
Barley	(mmbu/yr)	57.5	57.5	57.5	57.5

1/ portion of total road cost allocated to timber and agriculture development.

Table B-1. Alternative Parameters (continued)

Parameters	Unit	Alternatives 9	10	11	12
50-year analysis period	(beginning and ending)	0-50	0-50	0-50	0-50
Discount rate	(%)	7 5/8	7 5/8	10	10
Road costs:					
Overhead	(% of construction cost)	35	35	35	35
O&M	(% of construction cost)	1	1	1	1
Timber/ag cost share 1/	(%)	20	33 1/3	0	10
Clearing cost	($/ac)	300.00	300.00	250.00	300.00
Production cost:					
Barley - Class II land	($/ac)	146.69	146.69	175.30	175.30
Barley - Class III land	($/ac)	146.69	146.69	175.30	175.30
Logging	($/hr)	97.24	97.24	144.52	144.52
Overhead:					
Barley	(%)	20	20	17	17
Logging	(%)	20	20	20	20
Barley yield:					
Class II land	(bu/ac)	52.5	52.5	52.5	52.5
Class III land	(bu/ac)	47.5	47.5	47.5	47.5
Timber volume	(ft^3/ac)	1,246	1,246	1,246	1,246
Logging productivity	(ft^3/hr)	283.9	283.9	517.0	517.0
Prices:					
Barley	($/bu)	3.96	3.96	3.99	3.99
Spruce logs	($/MBF)	160.00	160.00	178.00	178.00
Cottonwood	($/MBF)	125.00	125.00	125.00	125.00
Fuelwood	($/cord)	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	(MBF/yr)	6,600	6,600	86,858	86,858
Fuelwood	(cords/yr)	11,000	11,000	98,764	98,764
Barley	(mmbu/yr)	57.5	57.5	82.75	82.75

1/ portion of total road cost allocated to timber and agriculture development.

Table B-1. Alternative Parameters (continued)

Parameters	Unit	Alternatives 13	14	15	16
50-year analysis period	(beginning and ending)	0-50	0-50	0-50	0-50
Discount rate	(%)	10	10	10	10
Road costs:					
Overhead	(% of construction cost)	35	0	35	35
O&M	(% of construction cost)	1	0	1	1
Timber/ag cost share[1/]	(%)	50	0	10	50
Clearing cost	($/ac)	325.00	250.00	300.00	325.00
Production cost:					
Barley - Class II land	($/ac)	175.30	177.52	177.52	177.52
Barley - Class III land	($/ac)	173.04	173.04	175.30	175.30
Logging	($/hr)	144.52	144.52	144.52	144.52
Overhead:					
Barley	(%)	17	17	17	17
Logging	(%)	20	20	20	20
Barley yield:					
Class II land	(bu/ac)	52.5	52.5	57.5	57.5
Class III land	(bu/ac)	47.5	47.5	52.5	52.5
Timber volume	(ft^3/ac)	1,246	1,246	1,246	1,246
Logging productivity	(ft^3/hr)	517.0	517.0	517.0	517.0
Prices:					
Barley	($/bu)	3.99	3.99	3.99	3.99
Spruce logs	($/MBF)	178.00	178.00	178.00	178.00
Cottonwood	($/MBF)	125.00	125.00	125.00	125.00
Fuelwood	($/cord)	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	(MBF/yr)	86,858	86,858	86,858	86,858
Fuelwood	(cords/yr)	98,764	98,764	98,764	98,764
Barley	(mmbu/yr)	82.75	82.75	82.75	82.75

1/ portion of total road cost allocated to timber and agriculture development.

Table B-1. Alternative Parameters (continued)

Parameters	Unit	Alternatives 17	18	19	20
50-year analysis period	(beginning and ending)	0-50	0-50	0-50	0-50
Discount rate	(%)	10	10	7 7/8	7 7/8
Road costs:					
Overhead	(% of construction cost)	0	0	0	0
O&M	(% of construction cost)	0	0	0	0
Timber/ag cost share 1/	(%)	0	0	10	10
Clearing cost	($/ac)	300.00	300.00	225.00	225.00
Production cost:					
Barley - Class II land	($/ac)	175.30	177.52	172.24	169.83
Barley - Class III land	($/ac)	173.04	175.30	172.24	169.83
Logging	($/hr)	144.52	144.52	144.00	144.00
Overhead:					
Barley	(%)	17	17	17	17
Logging	(%)	20	20	20	20
Barley yield:					
Class II land	(bu/ac)	52.5	57.5	55.0	55.0
Class III land	(bu/ac)	47.5	52.5	52.5	52.5
Timber volume	(ft^3/ac)	1,246	1,246	1,246	1,246
Logging productivity	(ft^3/hr)	517.0	517.0	413.6	465.0
Prices:					
Barley	($/bu)	0 2/	3.99	3.99	4.20
Spruce logs	($/MBF)	178.00	0 2/	178.00	178.00
Cottonwood	($/MBF)	125.00	0 2/	125.00	125.00
Fuelwood	($/cord)	75.00	0 2/	75.00	75.00
Demand ceilings:					
Sawlogs	(MBF/yr)	86,858	86,858	86,858	86,858
Fuelwood	(cords/yr)	98,764	98,764	98,764	98,764
Barley	(mmbu/yr)	82.75	82.75	82.75	82.75

1/ portion of total road cost allocated to timber and agriculture development.

2/ zero prices were used in order to enable the model to allocate all costs to either timber development or agricultural development.

Table B-1. Alternative Parameters (continued)

Parameters	Unit	Alternatives 21	22	23	24
50-year analysis period	(beginning and ending)	0-50	0-50	0-50	0-50
Discount rate	(%)	7 7/8	7 7/8	7 7/8	7 7/8
Road costs:					
Overhead	(% of construction cost)	0	0	0	0
O&M	(% of construction cost)	0	0	0	0
Timber/ag cost share 1/	(%)	10	10	10	10
Clearing cost	($/ac)	250.00	250.00	250.00	250.00
Production cost:					
Barley - Class II land	($/ac)	172.24	169.83	157.25	169.83
Barley - Class III land	($/ac)	172.24	169.83	157.25	169.83
Logging	($/hr)	144.00	144.00	144.00	172.00
Overhead:					
Barley	(%)	17	17	17	17
Logging	(%)	20	20	20	20
Barley yield:					
Class II land	(bu/ac)	55.0	55.0	55.0	55.0
Class III land	(bu/ac)	52.5	52.5	52.5	52.5
Timber volume	(ft^3/ac)	1,246	1,246	1,246	1,246
Logging productivity	(ft^3/hr)	568.7	517.0	517.0	517.0
Prices:					
Barley	($/bu)	4.20	3.99	3.99	4.20
Spruce logs	($/MBF)	178.00	178.00	178.00	178.00
Cottonwood	($/MBF)	125.00	125.00	125.00	125.00
Fuelwood	($/cord)	75.00	75.00	75.00	75.00
Demand ceilings:					
Sawlogs	(MBF/yr)	86,858	86,858	86,858	86,858
Fuelwood	(cords/yr)	98,764	98,764	98,764	98,764
Barley	(mmbu/yr)	82.75	82.75	82.75	82.75

1/ portion of total road cost allocated to timber and agriculture development.

Table B-1. Alternative Parameters (continued)

Parameters	Unit	Alternatives 25
50-year analysis period	(beginning and ending)	0-50
Discount rate	(%)	7 7/8
Road costs:		
Overhead	(% of construction cost)	0
O&M	(% of construction cost)	0
Timber/ag cost share[1/]	(%)	10
Clearing cost	($/ac)	225.00
Production cost:		
Barley - Class II land	($/ac)	169.83
Barley - Class III land	($/ac)	169.83
Logging	($/hr)	200.00
Overhead:		
Barley	(%)	17
Logging	(%)	20
Barley yield:		
Class II land	(bu/ac)	55.0
Class III land	(bu/ac)	52.5
Timber volume	(ft^3/ac)	1,246
Logging productivity	(ft^3/hr)	517.0
Prices:		
Barley	($/bu)	3.99
Spruce logs	($/MBF)	178.00
Cottonwood	($/MBF)	125.00
Fuelwood	($/cord)	75.00
Demand ceilings:		
Sawlogs	(MBF/yr)	86,858
Fuelwood	(cords/yr)	98,764
Barley	(mmbu/yr)	82.75

1/ portion of total road cost allocated to timber and agriculture development.

Table B-2. Alternative Results

Results	Unit	Alternatives 1	2	3	4
Total benefits	(thousand dollars) 1/	6,424	4,983	1,478	741
Net benefits	(thousand dollars)	2,218	1,605	510	239
B/C	(ratio)	1.53	1.48	1.53	1.48
Roads built:					
Length	(miles)	2.81	2.81	2.81	2.81
Cost	(thousand dollars) 2/	564	553	130	82
LP units accessed	(map no.)	8,17,18	8,17,18	8,17,18	8,17,18
Acres 3/ in production:					
Agriculture	(ac/yr)	-0-	-0-	-0-	-0-
Timber	(ac/yr)	556	556	556	556
Commodities produced:					
Barley	(thous. bu.)	-0-	-0-	-0-	-0-
Spruce sawlogs	(MBF)	782	782	782	782
Cottonwood sawlogs	(MBF)	714	714	714	714
Fuelwood	(cords)	3,842	3,842	3,842	3,842
Annual employment:					
Agriculture	(person years)	-0-	-0-	-0-	-0-
Timber	(person years)	6.1	6.1	6.1	6.1

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of O&M costs.

3/ These figures are on an annual basis. Since agricultural enterprises utilize the same acres year after year, the acreage figures for agriculture are total acres feasible for the evaluation period. Timber acreage, however, must be adjusted because different acres are utilized annually. To determine total feasible timber acres, multiply annual acres in production times length of the evaluation period in years. For example, the total feasible timber acres for alternative no. 1 is 556 acres times 50 years or 27,800 acres.

Table B-2. Alternative Results (continued)

Results	Unit	Alternatives 5	6	7	8
Total benefits	(thousand dollars) 1/	11,847	1,383	51,520	433,011
Net benefits	(thousand dollars)	684	244	2,984	15,173
B/C	(ratio)	1.06	1.21	1.06	1.04
Roads built:					
Length	(miles)	2.81	2.81	2.81	132.61
Cost	(thousand dollars) 2/	130	82	564	10,004
LP units accessed	(map no.)	8,17,18	8,17,18	8,17,18	1,2,4,5, 6,8,13, 14,15,17, 18,19,20, 21,37
Acres in production:					
Agriculture	(ac/yr)	17,984	2,096	17,984	156,016
Timber	(ac/yr)	323	556	323	1,593
Commodities produced:					
Barley	(thous. bu.)	944	110	944	8,191
Spruce sawlogs	(MBF)	454	782	454	2,239
Cottonwood sawlogs	(MBF)	414	714	414	2,044
Fuelwood	(cords)	2,229	3,842	2,229	11,000
Annual employment:					
Agriculture	(person years)	15.6	1.8	15.6	135.4
Timber	(person years)	3.5	6.1	3.5	17.4

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of O&M costs.

Table B-2. Alternative Results (continued)

Results	Unit	Alternatives 9	10	11	12
Total benefits	(thousand dollars) 1/	207,629	195,728	86,847	78,878
Net benefits	(thousand dollars)	9,963	6,251	47,753	26,581
B/C	(ratio)	1.05	1.03	2.22	1.51
Roads built:					
Length	(miles)	37.48	29.78	423.45	225.04
Cost	(thousand dollars) 2/	5,659	8,666	-0-	16,791
LP units accessed	(map no.)	5,8,13, 14,15,17, 18,19,20	5,8,15, 17,18, 19,20	All except LP Unit # 40	1,2,3,4, 5,6,8,13, 14,15,17, 18,19,20, 21,27,31, 32,36,37, 43,44,46, 47,49
Acres in production:					
Agriculture	(ac/yr)	71,208	66,944	-0-	-0-
Timber	(ac/yr)	1,593	1,543	9,434	8,568
Commodities produced:					
Barley	(thous. bu.)	3,738	3,515	-0-	-0-
Spruce sawlogs	(MBF)	2,239	2,170	13,259	12,043
Cottonwood sawlogs	(MBF)	2,044	1,761	12,107	10,996
Fuelwood	(cords)	11,000	10,659	65,144	6,700
Annual employment:					
Agriculture	(person years)	61.8	58.1	-0-	-0-
Timber	(person years)	17.4	16.9	79.6	72.3

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of O&M costs.

Table B-2. Alternative Results (continued)

Results	Unit	Alternatives 13	14	15	16
Total benefits	(thousand dollars) 1/	8,932	86,847	78,878	8,932
Net benefits	(thousand dollars)	2,893	47,753	26,581	2,893
B/C	(ratio)	1.48	2.22	1.51	1.48
Roads built:					
Length	(miles)	6.63	423.45	225.04	6.63
Cost	(thousand dollars) 2/	3,175	-0-	16,791	3,175
LP units accessed	(map no.)	5,8, 17,18	All except LP Unit # 40	1,2,3,4, 5,6,8,13, 14,15,17, 18,19,20, 21,27,31, 32,36,37, 43,44,46, 47,49	5,8, 17,18
Acres in production:					
Agriculture	(ac/yr)	-0-	-0-	-0-	-0-
Timber	(ac/yr)	970	9,434	8,568	970
Commodities produced:					
Barley	(thous. bu.)	-0-	-0-	-0-	-0-
Spruce sawlogs	(MBF)	1,364	13,259	12,043	1,364
Cottonwood sawlogs	(MBF)	1,245	12,107	10,996	1,245
Fuelwood	(cords)	6,700	65,144	59,166	6,700
Annual employment:					
Agriculture	(person years)	-0-	-0-	-0-	-0-
Timber	(person years)	8.2	79.6	72.3	8.2

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of O&M costs.

Table B-2. Alternative Results (continued)

Results	Unit	Alternatives			
		17	18	19	20
Total benefits	(thousand dollars) 1/	86,847	525,616	98,998	849,079
Net benefits	(thousand dollars)	47,753	24,150	31,796	52,660
B/C	(ratio)	2.22	1.05	1.47	1.07
Roads built:					
Length	(miles)	423.45	413.66	226.83	319.50
Cost	(thousand dollars) 2/	-0-	-0-	11,697	16,905
LP units accessed	(map no.)	All except LP Unit # 40	All except LP Unit # 11, 28,39	1,2,3,4, 5,6,8,13, 14,15,16, 17,18,19, 20,21,27, 31,32,36, 37,43,44, 46,47,49	All except LP Unit # 11,12,22, 23,25,33, 39,40,42, 45
Acres in production:					
Agriculture	(ac/yr)	-0-	219,528	-0-	271,576
Timber	(ac/yr)	9,434	-0-	8,591	6,812
Commodities produced:					
Barley	(thous. bu.)	-0-	12,623	-0-	14,782
Spruce sawlogs	(MBF)	13,259	-0-	12,074	9,575
Cottonwood sawlogs	(MBF)	12,107	-0-	11,025	8,743
Fuelwood	(cords)	65,144	-0-	59,320	47,041
Annual employment:					
Agriculture	(person years)	-0-	190.6	-0-	235.7
Timber	(person years)	79.6	-0-	90.6	63.9

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of O&M costs.

Table B-2. Alternative Results (continued)

Results	Unit	Alternatives 21	22	23	24
Total benefits	(thousand dollars) 1/	679,506	180,178	815,783	849,079
Net benefits	(thousand dollars)	53,898	43,333	70,394	52,466
B/C	(ratio)	1.09	1.32	1.09	1.07
Roads built:					
Length	(miles)	319.50	249.20	323.21	319.50
Cost	(thousand dollars) 2/	16,905	12,519	17,130	16,905
LP units accessed	(map no.)	All except LP Unit # 11,12,22, 23,25,33, 39,40,42, 45	All except LP Unit # 9,11,12, 22,23,24, 25,28,29, 30,33,34, 39,40,42, 45	All except LP Unit # 11,12,22, 23,25,33, 39,40,45	All except LP Unit # 11,12,22, 23,25,33, 39,40,42, 45
Acres in production:					
Agriculture	(ac/yr)	209,616	28,744	273,512	271,576
Timber	(ac/yr)	6,812	8,841	6,833	6,812
Commodities produced:					
Barley	(thous. bu.)	11,529	1,581	14,884	14,782
Spruce sawlogs	(MBF)	9,575	12,427	9,603	9,575
Cottonwood sawlogs	(MBF)	8,743	11,347	8,769	8,743
Fuelwood	(cords)	47,041	61,054	47,182	47,041
Annual employment:					
Agriculture	(person years)	181.9	24.9	237.4	235.7
Timber	(person years)	52.2	74.6	57.6	57.5

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of O&M costs.

Table B-2. Alternative Results (continued)

Results	Unit	Alternatives 25
Total benefits	(thousand dollars) 1/	158,113
Net benefits	(thousand dollars)	26,350
B/C	(ratio)	1.20
Roads built:		
Length	(miles)	224.39
Cost	(thousand dollars) 2/	11,586
LP units accessed	(map no.)	All except LP Unit # 1,2,3,4, 5,6,8,13, 14,15,17, 18,19,20, 21,27,31, 32,36,37, 43,44,46, 47,49
Acres in production:		
Agriculture	(ac/yr)	21,800
Timber	(ac/yr)	8,568
Commodities produced:		
Barley	(thous. bu.)	1,199
Spruce sawlogs	(MBF)	12,042
Cottonwood sawlogs	(MBF)	10,996
Fuelwood	(cords)	59,166
Annual employment:		
Agriculture	(person years)	18.9
Timber	(person years)	72.3

1/ All dollar figures are 1983 values.

2/ Includes overhead and present value of O&M costs.

APPENDIX C

A Methodology for Estimating Road Costs in the Susitna River Basin

The information presented here was developed at the request of the Alaska Department of Natural Resources.

All costs shown are rough estimates only and are not meant to be used as a substitute for "on the ground" reconnaissance and subsequent detailed design and cost work. The purpose of this information is to enable planners and others to identify the more desirable routes of access by means of establishing <u>relative</u> costs among route selection alternatives.

This paper is divided into four sections as follows:

1. Initial Construction
2. Associated Costs
3. Operation, Maintenance, and Replacement
4. Total Cost Summary (Example of route selection process)

<u>Initial Construction</u>

Initial construction costs include those costs incurred "up front" for actual on-the-ground construction of the road. These costs are addressed here in the following eight categories:

1. cut and fill
2. cut and waste
3. backfill
4. surface material
5. clearing
6. seeding
7. culverts
8. bridges

The first six are largely a function of slope and soil drainage, while the latter two, culverts and bridges, are a function of drainage patterns and slope. Engineering quantity and cost estimates have been made for construction of gravel roads of varying widths on four types of soil and five slope categories; this information is provided in Table 1.[1/] To actually estimate the total initial construction cost of various routes, it is necessary to evaluate each route on a case-by-case basis to determine culvert and/or bridge requirements. Once this determination has been made, bridge and culvert costs can be estimated and <u>added</u> to costs provided in Table 1 to arrive at total initial construction costs. Criteria for estimating bridge and culvert requirements are presented in Table 2.

1/ Basic data used to develop this table are found in Notes to Appendix B of <u>The Susitna Cooperative River Basin Study Economic Development Analysis; Talkeetna Subbasin, 1983</u>.

Table 1

Soil Drainage Category	Percent Slope	Road Cost[1/] as Function of Top Width									
		18' Cost Per:		24' Cost Per:		32' Cost Per:		36' Cost Per:		40' Cost Per:	
		L.F.	Mile	L.F.	Mile	L.F.	Mile	L.F.	Mile	L.F.	Mile
Well Drained	0-3	21.43	113,100	28.57	150,800	38.09	201,100	42.86	226,300	47.62	251,416
	4-7	35.00	184,800	46.66	246,400	62.21	328,500	69.99	369,500	77.77	410,600
	8-12	55.36	292,300	73.81	389,700	98.41	519,600	110.72	584,600	123.02	649,500
	13-20	155.33	820,100	207.10	1,093,500	276.13	1,458,000	310.65	1,640,200	345.17	1,822,500
	21-30	233.27	1,231,600	311.02	1,642,200	414.69	2,189,600	466.53	2,463,300	518.37	2,737,000
Poorly Drained	0-3	52.27	276,000	69.69	368,000	92.92	490,600	104.54	551,900	116.15	613,300
	4-7	63.18	333,600	84.24	444,800	112.32	593,000	126.36	667,200	140.40	741,300
	8-12	70.37	371,600	93.83	495,400	125.11	660,600	140.75	743,100	156.38	825,700
	13-20	198.28	1,046,900	264.37	1,395,900	352.49	1,861,200	396.56	2,093,800	440.62	2,326,500
	21-30	294.52	1,555,100	392.69	2,073,400	523.59	2,764,500	589.04	3,110,100	654.48	3,455,700
Shallow Peat	0-3	57.79	305,100	77.05	406,800	102.73	542,400	115.58	610,200	128.42	678,000
	4-7	79.37	419,000	105.82	558,700	141.09	745,000	158.73	838,100	176.37	931,200
Deep Peat	0-3	110.35	582,600	147.13	776,800	196.17	1,035,800	220.70	1,165,300	245.22	1,294,700

1/ Dollars - projected 2nd half, 1983.

Table 2. Bridge and Culvert Size Requirements 1/

Drainage Area of Stream at Proposed Road Crossing (Square Miles)	Culvert or Bridge Requirements	Cost Per LF of Culvert (dollars)
Less than 0.3	one 2' diameter culvert	36.25/LF
0.3 - 1.0	one 4' diameter culvert	108.75/LF
1.0 - 2.0	one 6' diameter culvert	217.50/LF
2.0 - 5.0	one 8' diameter culvert	290.00/LF
5.0 - 10.0	two 8' diameter culverts	580.00/LF
10.0 - 20.0	three 8' diameter culverts	870.00/LF
20.0 - 25.0	four 8' diameter culverts	1,150.00/LF
Greater than 25.0	bridge	101.50/Ft.^{2}

1/ It is emphasized that this is a "short-cut" method of determining requirements. Other factors, including discharge and fisheries impact, should always be considered prior to any actual construction.

Engineers have assumed that road crossings at streams with a drainage area in excess of 25 square miles will require bridge construction. Bridge costs are estimated to be $101.50/sq. ft. Since fixed costs are such a large portion of total bridge costs, and since any planned route may be upgraded in the future, it is unlikely that any bridge less than 32 feet in width would be constructed. As a result, bridge costs per linear foot for roads of varying width are estimated to be as follows:

Road Width	Bridge Cost per L.F. of road
18'	$3,248
24'	$3,248
32'	$3,248
36'	$3,654
40'	$4,060

Culverts would be necessary at many road crossings where stream drainage areas are less than 25 square miles. Table 2 provides information concerning culvert size (diameter) requirements and unit costs as a function of stream drainage area. Table 3 indicates the length of culverts required for varying road widths given alternative slope conditions. Table 4 is a product of Tables 2 and 3 and shows total culvert costs as a function of road width, slope, and stream drainage area.

Table 3. Culvert Length Requirements

	Culvert Length as Function of Road Width				
Percent Slope	18' Width	24' Width	32' Width	36' Width	40' Width
0 - 3	46'	52'	60'	64'	68'
4 - 7	66'	72'	80'	84'	88'
8 - 12	81'	87'	95'	99'	103'
13 - 20	223'	229'	237'	241'	245'
21 - 30	316'	322'	330'	334'	338'

Table 4. Culvert Costs by Drainage Area and Road Width

Percent Slope	Drainage Area at Road Crossing (Square Miles)	Road Width 18' Width	24' Width	32' Width	36' Width	40' Width
	Less than 0.3	$ 1,668	$ 1,885	$ 2,175	$ 2,320	$ 2,465
	0.3 - 1.0	5,003	5,665	6,525	6,960	7,395
	1.0 - 2.0	10,005	11,310	13,050	13,920	14,790
0 - 3	2.0 - 5.0	13,340	15,080	17,400	18,560	19,720
	5.0 - 10.0	26,680	30,160	34,800	37,120	39,440
	10.0 - 20.0	40,020	45,240	52,200	55,680	59,160
	20.0 - 25.0	53,360	60,320	69,600	74,240	78,880
	Less than 0.3	2,393	2,610	2,900	3,045	3,190
	0.3 - 1.0	7,178	7,830	8,700	9,135	9,570
	1.0 - 2.0	14,355	15,660	17,400	18,270	19,140
4 - 7	2.0 - 5.0	19,140	20,880	23,200	24,360	25,520
	5.0 - 10.0	38,280	41,760	46,400	48,720	51,040
	10.0 - 20.0	57,420	62,640	69,600	73,080	76,560
	20.0 - 25.0	76,560	83,520	92,800	97,440	102,080
	Less than 0.3	2,936	3,154	3,444	3,589	3,734
	0.3 - 1.0	8,809	9,461	10,331	10,766	11,201
	1.0 - 2.0	17,618	18,923	20,663	21,533	22,403
8 - 12	2.0 - 5.0	23,490	25,230	27,550	28,710	29,870
	5.0 - 10.0	46,980	50,460	55,100	57,420	59,740
	10.0 - 20.0	70,470	75,690	82,650	86,130	89,610
	20.0 - 25.0	93,960	100,920	110,200	114,840	119,480
	Less than 0.3	8,084	8,301	8,591	8,736	8,881
	0.3 - 1.0	24,251	24,904	25,774	26,209	26,644
	1.0 - 2.0	48,503	49,808	51,548	52,418	53,288
13 - 20	2.0 - 5.0	64,670	66,410	68,730	69,890	71,050
	5.0 - 10.0	129,340	132,820	137,460	139,780	142,100
	10.0 - 20.0	194,010	199,230	206,190	209,670	213,150
	20.0 - 25.0	258,680	265,640	274,920	279,560	284,200
	Less than 0.3	11,455	11,673	11,963	12,108	12,253
	0.3 - 1.0	34,365	35,018	35,888	36,323	36,758
	1.0 - 2.0	68,730	70,035	71,775	72,645	73,515
21 - 30	2.0 - 5.0	91,640	93,380	95,700	96,860	98,020
	5.0 - 10.0	183,280	186,760	191,400	193,720	196,040
	10.0 - 20.0	274,920	280,140	287,100	290,580	294,060
	20.0 - 25.0	366,560	373,520	382,800	387,440	392,080

Associated Costs

Once total initial construction costs have been estimated, additional costs must be included to account for associated activities. These costs are expressed as a function (percentage) of total initial construction cost and are as follows:

Item	Percent
1. Engineering services - design, soil testing, quantity and cost computations, survey work, etc.	20
2. Mobilization - transportation of construction equipment to the work site and maintaining it at this location.	10
3. Contract Admin./Construction Inspection - administration of contract, meals and lodging, on-site inspection of construction activities, and materials.	12
4. Contingencies - unforeseen problems in construction and/or other associated items.	10
Total	52

It is important to note that the percentages provided above are estimates from the Alaska Department of Transportation. Depending on the agency or authority involved, these costs may vary greatly. At present, for example, the Matanuska-Susitna Borough estimates its total associated costs to be roughly 35% of initial construction.

Operation, Maintenance, and Replacement (OM&R)

In contrast to initial costs (both construction and associated) which are incurred at one point in time, OM&R costs occur on a continual or repetitive schedule. Generally, O&M takes place on an annual basis, while replacement occurs at various intervals depending upon the "life" of the item to be replaced.

For this analysis, the evaluation period is assumed to be 50 years. During this period O&M will occur annually and is estimated to be $4,727/mile/year1/. The expected life of culverts and bridges is assumed to be 25 and 50 years respectively. In order to put O&M and Replacement costs on a par with initial costs, it is necessary to determine their "Present Value" (initial construction and associated costs discussed in previous sections are already on a "present value" basis). Present value is

1/ See Notes to Appendix B of The Susitna Cooperative River Basin Study Economic Development Analysis; Talkeetna Subbasin, 1983 for derivation of annual O&M cost.

a function of both discount rates and time. Since the time period is known--every year for O&M and once every 25 years for culverts1/, only the discount rate is important.

The following alternative factors can be applied to annual O&M costs and culvert costs to determine their present value.

Item	Annual Discount Rate (%)						
	8	9	11	12	13	14	15
O & M 2/	12.233	10.962	9.915	9.042	8.304	7.675	7.133
Replacement 3/ (Culverts)	0.146	0.116	0.092	0.074	0.059	0.047	0.038

To illustrate how those figures should be used, the following examples are provided:

Example 1 - The present value of annual O&M per mile, given a 10% discount rate, is $4,727 4/ x 9.915 or $46,868.

Example 2 - The present value of replacing a 4 ft. diameter culvert5/, 72 ft. in length, given a 10% discount rate, is $7,830 (see Tables 2, 3, and 4) x 0.092 or $720.

It is important to note that no associated cost percentages should be applied to O&M or replacement costs because generally these are part of an on-going program.

1/ Since the life of a bridge is equal to the evaluation period (50 years) no bridge replacement costs need be factored into the analysis.

2/ Present value of a constant annuity of 1 per year for 50 years.

3/ Present value of 1, 25 years hence.

4/ See Notes to Appendix B of The Susitna Cooperative River Basin Study Economic Development Analysis; Talkeetna Subbasin, 1983 for derivation of Annual O&M cost.

5/ Size of culvert required where road width is 24', terrain is 4-7% slope, and stream drainage area is 0.3-1.0 square miles above road crossing.

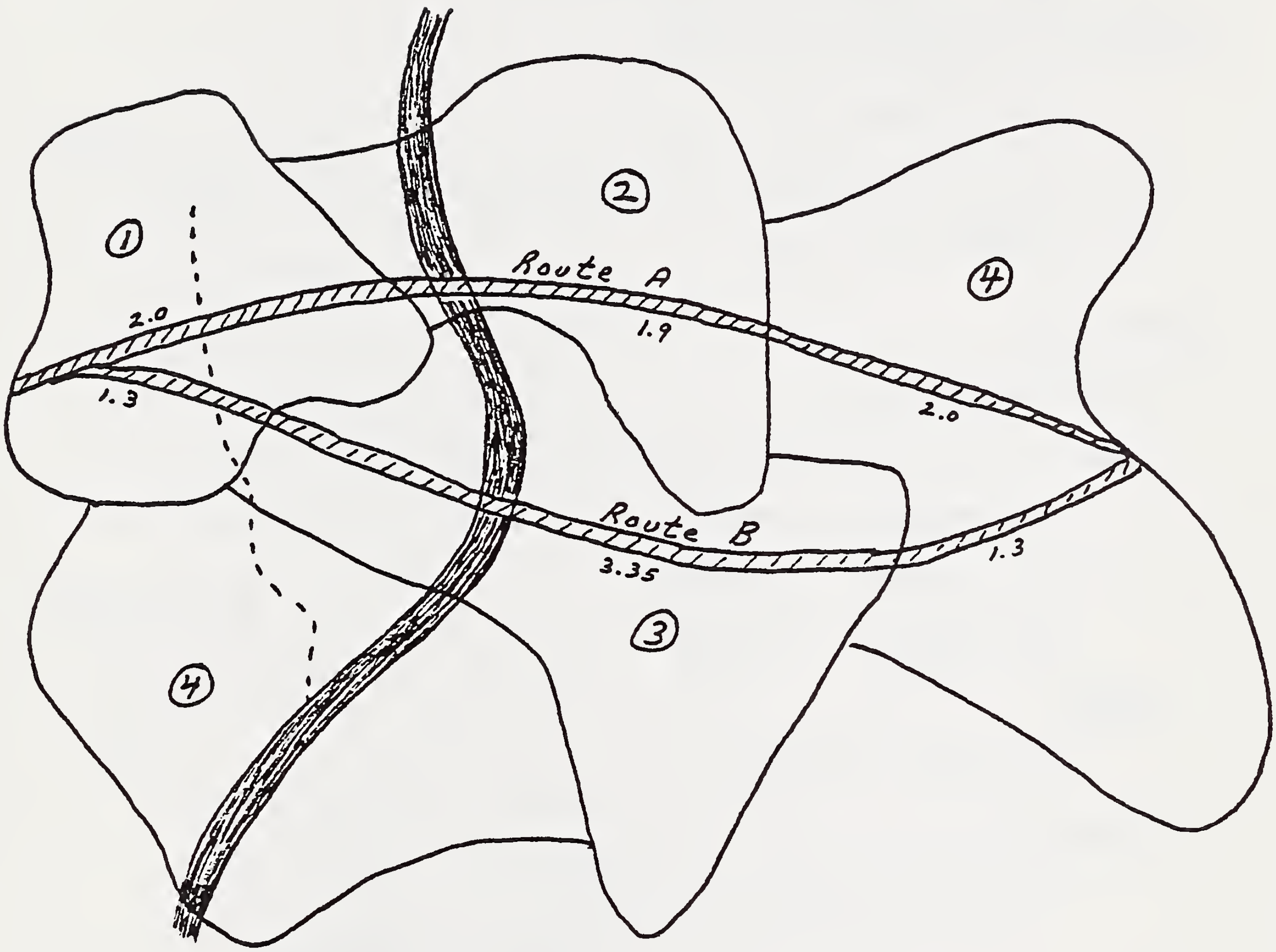
Total Cost Summary[1/]

The information presented in the previous sections will enable planners and others to estimate relative costs of alternative access routes. The example provided on the following pages illustrates a typical situation and can serve as a guide to those utilizing the information presented here.

1/ No land rights costs have been addressed in this analysis due to their high variability. Those using this methodology should, however, be aware that, depending upon proposed road location, land rights may be an important factor in the route selection process.

Scale: 1 inch = 1 mile

Total road cost example



Key:

① = Well-drained soil area - 4-7 percent slope

② = Deep peat soil area - 0-3 percent slope

③ = Poorly-drained soil area - 0-3 percent slope

④ = Well-drained soil area - 8-12 percent slope

= Proposed route

= Major stream drainage area = 50 mi^2

---- = Tributary drainage area = 3.6 mi^2

ROUTE A   Given:

1. Width of Road = 24 feet
2. Miles of Road in 1 = 2.0
3. Miles of Road in 2 = 1.9
4. Miles of Road in 4 = 2.0
5. Length of bridge required at major road crossing = 42 feet
6. Discount Rate = 10%

COMPUTATIONS:

I. Initial Construction

Road

2.0 x 246,400 = 492,800

1.9 x 776,800 = 1,475,920

2.0 x 389,700 = 779,400

Bridge

42 x 3,248 = 136,416

Culverts

1 at 20,880 (Table 4) = 20,880

Subtotal = $2,905,416

II. Associated Costs

2,909,766 x 52% = $1,510,816

III. O&M

(a) 2.0 + 1.9 + 2.0 = 5.9 miles

(b) 5.9 miles x 4,727/mile annually = $27,889

(c) Present value = 9.915 x 27,889 = $276,522

IV. Replacement

20,880 x .092 = <u>$1,921</u>

GRAND TOTAL (ROUTE A) = <u>$4,694,675</u>

<u>ROUTE B</u> Given:

1. Width of Road = 24 feet
2. Miles of Road in 1 = 1.3
3. Miles of Road in 3 = 3.35
4. Miles of Road in 4 = 1.3
5. Length of bridge required at major road crossing = 42 feet
6. Discount Rate = 10%

COMPUTATIONS:

I. Initial Construction

<u>Road</u>

1.3 x 246,400 = 320,320

3.35 x 368,000 = 1,232,800

1.3 x 389,700 = 506,610

<u>Bridge</u>

42 x 3,248 = 136,416

<u>Culverts</u>

1 at 20,880 (Table 4) = 20,880

Subtotal = <u>$2,217,026</u>

II. Associated Costs

2,221,376 x 52% = <u>$1,152,854</u>

III. O&M

(a) 1.3 + 3.35 + 1.3 = 5.95 miles

(b) 5.95 miles x 4,727/mile annually = 28,126

(c) Present value

9.915 x 28,126 = <u>$278,866</u>

IV. Replacement

20,880 x .092 = <u>$1,921</u>

GRAND TOTAL (ROUTE B) = <u>$3,650,667</u>

APPENDIX D

Computer Models for Land Suitability:

1) Moderate/high density residential development

2) Moose habitat

3) Roads

Excerpted from: Final Report - Computerized Geographic Information System, Talkeetna and Beluga Subbasins, Susitna River Basin, Alaska (ESRI 1982)

MODEL OUTLINE
LAND CAPABILITY FOR MODERATE/HIGH DENSITY RESIDENTIAL DEVELOPMENT

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
Landform Type	Glacial		
	Moraine	H	
	Till	H	
	Drumlin		
	Drumlin/Drumloid	H	
	Rock Drumlin	NR	
	Fluvioglacial		
	Outwash	H	
	Abandoned Outwash Channel	H	
	Remnant Subglacial Stream Valley	H	
	Kame Complex	H	
	Esker	H	
	Crevasse Filling	H	
	Side Glacial Drainage Channel	H	
	Flute	H	
	Aeolian		
	Dune	L	
	Littoral		
	Longshore Bar	U	
	Beach	U	
	Barrier Spit	U	
	Delta	L	
	Tidal Flat	U	
	Coastal Plain	NR	
	Fluvial		
	Active Channel	U	
	River Bar	U	
	Floodplain		
	Active	U	
	Abandoned	NR	
	Alluvial Plain	H	
	Alluvial Fan/Cone	H	
	Lacustrine Deposit	H	
	Mass Wasting		
	Colluvium	U	
	Talus	U	
	Landslide Deposit	U	
	Rock Glacier	U	
	Mine Tailings	U	

H = high
M = moderate
L = low
U = unsuitable
NR = not rated

MODEL OUTLINE
LAND CAPABILITY FOR MODERATE/HIGH DENSITY RESIDENTIAL DEVELOPMENT (continued)

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
	Tectonic Uplift		
	Upland Valley	H	
	Mountain Sideslope	NR	
	Mountain Ridgetop	NR	
	Waterbody	U	
	Ice and Snow	U	
Slope Gradient	Average Slope Gradient		
	0 - 3 %	H	
	3 - 7 %	H	
	7 - 12 %	H	
	12 - 20 %	M	
	20 - 30 %	L	
	30 - 45 %	U	
	GT 45 %	U	
	Specific Slope Phase		
	0 - 3 %	H	
	3 - 7 %	H	
	7 - 12 %	H	
	12 - 20 %	M	
	20 - 30 %	L	
	30 - 45 %	L	
	GT 45 %	U	
Geologic Hazard	Primary Potential Flood Zone	U	
	Secondary Potential Flood Zone	NR	
	Outburst Flood Zone	U	
	Catastrophic Wave Zone	U	
	Landslide Zone	U	
	Varying Particle Size	NR	
	Unstable Ground	NR	
	Avalanche Track	U	
Soil Characteristics	Limitations for Dwellings With Basements		
	Slight	H	
	Moderate	M	
	Severe	L	
	Limitations for Dwellings Without Basements		
	Slight	H	
	Moderate	M	
	Severe	L	

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
	Limitations for Local Roads and Streets		
	Slight	H	
	Moderate	H	
	Severe	M	
	Drainage		
	Excessively Drained	M	
	Somewhat Excessively Drained	H	
	Well Drained	H	
	Moderately Well Drained	M	
	Somewhat Poorly Drained	L	
	Poorly Drained	U	
	Very Poorly Drained	U	
	Ice	U	
Water Availability	Non Glacial		
	Stream (GE2nd Order)		
	LE1 Mile Distance	NR	
	GT1 Mile Distance		
	If Potential Well Yield Area 1	L	
	If Potential Well Yield Area 2 or 3	NR	

MODEL SUMMATION RULES

Ratings are scanned within each general category encompassing more than one factor and the most severely constraining rating is used to provide the overall rating for the category. In effect, each general consideration - landform, soils, water availability, etc., - has a single rating when summation begins. The following summation procedures are used:

High Capability	GE1H and Not EQ M L or U
Moderate Capability	EQ1 or 2M and Not EQ L or U
Low Capability	GT2M or EQ1 or 2L and Not EQ U
Incapable	GT2L or GE1U

GE = greater than or equal to ...
EQ = equal to ...
GT = greater than ...

MODEL OUTLINE
MOOSE HABITAT

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
Primary Vegetation	Closed Forest		
	Coniferous Forest, White Spruce, Short Stands	3	
	Deciduous Forest, Mixed Forest, Young Stands	2	
	Deciduous Forest, Mixed Forest, Medium-Aged Stands	1	
	Coniferous Forest, White Spruce, Tall Stands	1	
	Deciduous Forest, Mixed Forest, Old Stands	2	
	Cottonwood-Young Stands	1	
	Cottonwood-Medium Age Stands	3	
	Cottonwood-Old Stands	3	
	Open Forest-Woodland		
	Coniferous Forest, White Spruce, Short Stands	2	
	Deciduous Forest, Mixed Forest, Medium-Aged Stands	2	
	Coniferous Forest, White Spruce, Tall Stands	2	
	Deciduous Forest, Mixed Forest, Old Stands	3	
	Cottonwood-Medium Aged Stands	5	
	Cottonwood-Old Stands	3	
	Closed Forest (Black Spruce Mountain Hemlock)		
	Black Spruce, Short Stands	4	
	Black Spruce, Tall Stands	4	
	Mountain Hemlock, Tall Stands	1	
	Open Forest-Woodland (Black Spruce)		
	Black Spruce, Short Stands	5	
	Saltwater Wetland		
	Salt Grassland	9	
	Low Shrub	9	
	Tidal Marsh	9	
	Tall Shrubs		
	Alder	3	
	Alder-Willow	1	

MODEL OUTLINE
MOOSE HABITAT (continued)

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
	Low Shrub		
	Willow Resin Birch		6
	Grassland		
	Upland Grass		6
	Tundra		
	Sedge-Grass		8
	Herbaceous		6
	Shrub		7
	Mat and Cushion		8
	Fresh Water Wetlands		
	Sphagnum-Bog	9	
	Sphagnum-Shrub Bog		7
	Cultural Features		
	Cultural Influences	10	
	Barren		
	Mud Flats	10	
	Rock	10	
	Permanent Snow and Ice		
	Snowfield	10	
	Glacier	10	
	Water	11	

MODEL SUMMATION RULES

VALUES 1-4 = LEVEL 1 MOD/HIGH WR, (S/S/F) RANGE
VALUES 6-7 = LEVEL 2 MOD/HIGH (S/S/F) RANGE, NO WR
VALUES 5, 8-10 = LEVEL 3 LOW TO NO HABITAT
VALUES 11 = LEVEL 4 WATER

MOD/HIGH = moderate to high value for ...
WR = winter range
S/S/F = spring, summer, fall

MODEL OUTLINE
ROAD SUITABILITY
TALKEETNA SUBBASIN

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
Landform Type (Rating 1 to 10, 1 is best)			
	Glacial		
	Moraine	4	
	Till	4	
	Drumlin		
	Drumlin/Drumloid	3	
	Rock Drumlin	7	
	Fluvioglacial		
	Outwash	3	
	Abandoned Outwash Channel	3	
	Remnant Subglacial Stream Valley	4	
	Kame Complex	2	
	Esker	1	
	Crevasse Filling	1	
	Side Glacial Drainage Channel	3	
	Flute	3	
	Aeolian		
	Dune	7	
	Littoral		
	Longshore Bar	8	
	Beach	8	
	Barrier Spit	8	
	Delta	9	
	Tidal Flat	9	
	Coastal Plain	9	
	Fluvial		
	Active Channel	8	
	River Bar	6	
	Floodplain		
	Active	7	
	Abandoned	4	
	Alluvial Plain	3	
	Alluvial Fan/Cone	2	
	Lacustrine Deposit	9	
	Mass Wasting		
	Colluvium	10	
	Talus	10	
	Landslide Deposit	10	
	Rock Glacier	10	
	Mine Tailings	5	

MODEL OUTLINE
ROAD SUITABILITY (continued)
TALKEETNA SUBBASIN

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
	Tectonic Uplift		
	Upland Valley	7	
	Mountain Sideslope	10	
	Mountain Ridgetop	10	
	Waterbody	10	
	Ice and Snow	10	
Slope Gradient (Rating is 1 to 40, 1 is best)	Slope Gradient		
	Level or Nearly Level	1	
	Gently Sloping	2	
	Undulating	2	
	Sloping (Moderately)	3	
	Rolling	3	
	Strongly Sloping	5	
	Hilly	5	
	Moderately Steep	15	
	Steep	20	
	Very Steep	30	
	Extremely Steep	30	
	Water	30	
	Ice	30	
Geologic Hazard (Rating is 1 to 10, 1 is best)	Primary Potential Flood Zone	10	
	Primary Flood Zone/ Wave Zone	10	
	Secondary Potential Flood Zone	5	
	Secondary Flood Zone/ Wave Zone	5	
	Outburst Flood Zone	10	
	Catastrophic Wave Zone	10	
	Landslide Zone	10	
	Varying Particle Size	5	
	Unstable Ground	10	
	Avalanche Track	10	
Soil Characteristics (Rating is 1 to 10, 1 is best)	Limitations for Local Roads and Streets		
	Slight	1	
	Moderate	5	
	Severe	10	
	Water	10	

MODEL OUTLINE
ROAD SUITABILITY (continued)
TALKEETNA SUBBASIN

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
(Rating is 1 to 15, 1 is best)	Drainage		
	Excessively Drained	1	
	Somewhat Excessively Drained	1	
	Well Drained	1	
	Moderately Well Drained	2	
	Somewhat Poorly Drained	5	
	Poorly Drained	10	
	Very Poorly Drained	15	
	Ice	15	
	Water	15	
(Rating is 1 to 10, 1 is best)	Source Road Fill		
	Good	1	
	Fair	5	
	Poor	10	
	Water	15	
(Rating is 1 to 15, 1 is best)	From Good		
	If $\leq$ 1/2 Mile	1	
	If > 1/2 Mile $\leq$ 1 Mile	2	
	If > 1 Mile $\leq$ 2 Miles	4	
	If > 1 Mile $\leq$ 3 Miles	6	
	If > 3 Miles $\leq$ 4 Miles	8	
	If > 4 Miles $\leq$ 5 Miles	10	
	If > 5 Miles	10	
Vegetation Cover (Rating is 1 to 40, 1 is best)	Closed Forest (GE 50% Crown Cover)	10	
	Open Forest (GE 10% to LT 50% Crown Cover)	6	
	Non Forest (LT 10% Crown Cover)		
	Salt Water Wetland		
	Grassland	40	
	Low Shrub	40	
	Tidal Marsh	40	
	Tall Shrub		
	Alder	4	
	Alder-Willow	4	
	Low Shrub		
	Willow-Resin Birch	2	
	Grassland		
	Grassland	1	

Consideration	Specific Data Class	Value (incidence)	Value (proximity)
	Tundra		
	Sedge-Grass	20	
	Herbaceous	15	
	Shrub	20	
	Mat-Cushion	20	
	Freshwater		
	Sphagnum Bog	30	
	Sphagnum-Shrub Bog	30	
	Cultural		
	Cultural Influence	1	
	Barren		
	Mud Flats	40	
	Rock	40	
	Snow		
	Snow Field	40	
	Glacier	40	
	Water		
	Lake GE 40 Acres	40	
	Lake GE 10 Acres and LT 40 Acres	40	
	Stream or River GE 165 Feet Wide and LT 550 Feet Wide	40	
	River GE 600 Feet Wide	40	
	Stream or River LT 165 Feet Wide	40	

MODEL SUMMATION RULES

High	Less than 10
Moderate High	11 - 15
Moderate	16 - 30
Low	31 - 60
Very Low	61 - 100
Extremely Low	101 - 150

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